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APPLIED MECHANICS REVIEWS

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NUMERICAL WEATHER PREDICTION

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WEATHER prediction is currently undergoing a gradual transition from an essentially subjective art to an objective science. By and large, the forecaster has had to base his predictions on a judicious combination of past experience and qualitative physical reasoning, his most useful tool being that of simple extrapolation of the previous behavior of a given weather system. However, the development of high-speed electronic computers since the end of World War II has made it feasible to attack the prediction problem by more objective and quantitative methods, and a substantial portion of recent research in meteorology has been devoted to this goal. From this work two methods have emerged which show promise for the future: *statistical* forecasting attempts to derive prediction formulas from the known behavior of the atmosphere in the past, while *dynamical* forecasting attempts to derive its prediction formulas from the laws of physics as they apply to the atmosphere. The ultimate forecasting schemes will undoubtedly be a combination of the two methods, and, in fact, successful use of each method so far has depended to some small extent on an exploitation of information obtained by the other method.

The present writers have been associated with the dynamical approach to weather prediction, and this article will therefore concentrate on weather prediction by dynamical methods. Several reviews of the subject have been made, the most thorough being that by Charney (2) in 1950. Since that time considerable experience has been gained with the dynamical method, and routine forecasts of this type have now been prepared for several years by the Joint Numerical Weather Prediction Unit (JNWP) in this country and also by a group at the Institute for Meteorology at the University of Stockholm. Definite plans for at least semi-operational use of this method with electronic computers seem to be underway in England, Germany, Israel, Japan, Norway, and the USSR.

THE PHYSICAL BASIS FOR DYNAMICAL WEATHER PREDICTION

Stated very crudely, numerical weather prediction is simply the numerical finite-difference solution of the equations of motion for the atmosphere. These equations may be written in the following form:

$$\left\{\begin{matrix}\text{Equation}\\ \text{of motion}\end{matrix}\right\} \frac{\partial \mathbf{v}}{\partial t} = -\mathbf{v}\cdot\nabla\mathbf{v} - 2\omega\times\mathbf{v} - \frac{1}{\rho}\nabla p - \mathbf{g} + \mathbf{F},$$

$$\left\{\begin{matrix}\text{First law of}\\ \text{Thermodynamics}\end{matrix}\right\} \frac{\partial s}{\partial t} = -\mathbf{v}\cdot\nabla s + \frac{Q}{T},$$

$$\left\{\begin{matrix}\text{Continuity}\\ \text{Equation}\end{matrix}\right\} \frac{\partial \rho}{\partial t} = -\nabla\cdot\rho\mathbf{v},$$

$$\left\{\begin{matrix}\text{Equation}\\ \text{of State}\end{matrix}\right\} p = p(s,\rho)\ ;\ T = T(s,\rho),$$

where $\mathbf{v}$ is the velocity relative to the rotating earth, p, ρ, T, and s are pressure, density, temperature, and specific entropy. ω is the angular velocity of the earth and $\mathbf{g}$ is the apparent acceleration of gravity. $\mathbf{F}$, the frictional force per unit mass, and Q, the rate of absorption of thermodynamic energy per unit mass, are assumed to be expressible in terms of the other quantities.

The numerical solution of these equations (in practice, simplified versions must be used, as indicated below) proceeds by first representing the continuous space and time coordinates by a finite-difference grid network in space (Δx, *say*) and time (Δt). The right hand sides (of the first three) can be evaluated at time t, using finite-difference approximations to the space derivatives where they appear, and, when multiplied by Δt, can then be added to $\mathbf{v}$, s, or ρ at time t to give the corresponding quantity at time $t + \Delta t$ at each point of space grid. This process can then be iterated n times until $n\Delta t$ is equal to the period of the desired forecast. Boundary conditions are needed of course, and centered differences must normally be used in both space and time, but the main idea is as outlined here. The artifice of replacing the derivatives by differences is necessary because the nonlinear terms (e.g., $\mathbf{v}\cdot\nabla\mathbf{v}$) make an analytic solution of the problem hopeless at the present time. Its validity depends on the size of Δx and Δt relative to the space and time scales of the motion which are to be described.

SPECIFIC PROBLEMS ENCOUNTERED IN APPLICATION

Several types of problems arise in the application of this scheme to weather forecasting.

a. Inadequate specification of the initial data. In order to make a dynamical forecast it is necessary to specify, at a given instant, the distribution throughout the atmosphere of the variables in the above equations. At the present time, there exist about 400 meteorological stations throughout the northern hemisphere at which temperature, humidity, hydrostatic pressure, and horizontal wind velocity are measured twice daily as a function of altitude above the observing station. (Very few measurements are made in the southern hemisphere.) These measurements generally extend up to a height of about 12 km or more, thereby including at least the lower 80% of the mass of the atmosphere. The horizontal distribution of the observations is such that over the continents the reports from each station must represent, *on the average,* conditions over an area of about $(500\ \text{km})^2$. Since most of the weather phenomena of middle and high latitudes is determined by motions on a scale of several thousand kms, this sampling probably approaches at least the minimum data requirements for dynamical weather prediction. Over the oceans, on the other hand, the available reports are so few that each station must represent conditions over an area of close to $(2000\ \text{km})^2$. This sampling is inadequate for the purposes of dynamical weather prediction and constitutes an important source of error in present forecasts.

b. Too great generality of the basic equations. The equations given in the previous section, except for the Coriolis acceleration $2\omega \times \mathbf{v}$, are also the same equations which describe ordinary sound propagation, the flow of air over an airplane wing, and other hydrodynamic flows in which such effects as compressibility, viscosity, and the presence of large accelerations are important features. On the other hand, the observational data for the meteorological problem is only barely adequate to specify initial conditions for motions of large space and time scales (which fortunately contain most of the atmospheric energy). Charney (8) has shown that motion on these scales (several thousand kms and several days) is practically horizontal and incompressible, and is further characterized by the fact that the relative accelerations are small compared to the forces on the right side of the above equation of motion. This means that $\partial \mathbf{v}/\partial t$ as computed from the above equation would depend on a very accurate evaluation of the terms on the right side. The "geostrophic" theory introduced by Charney has been quite successful in improving this state of affairs, and to date has formed the basis for almost all dynamical weather predictions. (A thorough discussion of this method is contained in (2); the general idea, however, is as follows. In addition to the hydrostatic approximation that $\partial p/\partial z = -\rho g$, the assumption is made that, in the horizontal equation of motion, the main terms are the Coriolis force and the pressure force, so that the wind is approximately equal to the geostrophic wind. By taking the curl of the original equations, the pressure term is eliminated, and judicious introduction of the geostrophic wind for the real wind in the resulting vorticity equation then yields a forecast equation in which the time derivatives are more representative.)

c. Computational stability. Broadly speaking, this is the problem of the error introduced by replacing continuous derivatives in a partial differential equation by finite differences, and was first discussed by Courant, Friedrichs and Lewy (48). In initial-value problems this places a limit on the allowable size of Δt, namely that the ratio $c\Delta t/\Delta x$ must be less than 1, where c is the largest possible phase speed allowed by the equations. (Additional criteria come into play when the equation contains viscous or frictional-type terms.) If sound waves were retained in the forecast scheme this would limit Δt to about 6 secs (for $\Delta z = 2$ km), so that there is a great computational advantage to be gained by eliminating the meteorologically unimportant sound waves and fast-moving gravity waves from the prediction scheme. The computations made so far have done this by using the geostrophic theory. In the stability criterion c then becomes the maximum particle velocity, which allows a Δt of 30 min or more (for a Δx of 300 km). Computational stability of this type has been discussed for the most part only for linearized equations (see however (51)). The adequacy of a given numerical scheme for solution of the *nonlinear* equations over forecast periods long enough for the nonlinearities to become important is a much more difficult matter to examine mathematically, and perhaps experience with various numerical integration procedures offers the only hope of treating this problem (49).

d. Frictional and nonadiabatic influences. $\mathbf{F}$ and Q can be related to the other variables when the equations are understood to include motions on the smallest possible scale (e.g., $\mathbf{F} = \nu\nabla^2\mathbf{v}$). However, when Δx is finite in size (normally about 300 km in the horizontal and 2–10 km in the vertical) the effective frictional forces (and also to some extent the, effective heat sources) arise rather from the nonlinear terms $\mathbf{v}\cdot\nabla\mathbf{v}$ (and $\mathbf{v}\cdot\nabla s$) acting on the (neglected) motions of a scale less than Δx, and can therefore no longer be related in a known manner to the large-scale motions. In most of the forecasts made to date this problem has been bypassed by limiting the forecasts to a period of 1–2 days, and simply ignoring $\mathbf{F}$ and Q. (Among other things, this has the natural result that cloud and precipitation must at present be inferred subjectively from the forecast field of motion.)

e. Lateral boundaries. Ideally the integration scheme should include the entire atmosphere, in which case there are no lateral boundaries. However, the dearth of data over the southern hemisphere, together with the present limited size of computers and the slowness of weather communications, has generally made it advisable to work with areas of about ¼ to ¾ of the (northern) hemisphere. As a result, the region in which the forecast is valid shrinks with time (at a rate approximately equal to the group velocity), and this must be allowed for in applying and judging the forecast results (9). Care must be still taken, however, in stating the finite-difference boundary conditions to avoid the introduction of computational instabilities (51). The analysis of this feature of the numerical scheme involves the determination of the eigenvalues of the complete computation matrix and becomes quite complicated even for a linearized (but 2-dimensional) system. Simple and stable boundary formulations have been developed for the geostrophic equations, but stable boundary schemes for the original system of equations (in which only the hydrostatic assumption is made) seem to be more difficult to formulate (at least when the air is allowed to pass through the boundaries) and present a challenging problem in the field of numerical analysis.

RESULTS OF SHORT-RANGE DYNAMICAL FORECASTS

There is now an accumulation of several years of experience with geostrophic numerical predictions over periods of several days. The simplest of these prediction schemes deals only with the vertically-averaged horizontal flow patterns, and is called the "barotropic" model since the resulting equations are identical with those for a horizontally moving, incompressible fluid of uniform density (20). The next simplest model has 2 degrees of freedom in the vertical, thereby introducing the possibility of conversion of potential energy into kinetic energy—a process which seems to be associated with the deepening and formation of new storms. The former model gives a forecast only of the mean flow pattern (which can be roughly identified with that at about the 5-km level), while the "2-level" model also attempts to indicate surface developments. A brief summary of the results of this experience is as follows:

1. The barotropic model does rather well, even up to periods of 2–3 days, if the forecast region is large enough (approximately ¾ of the hemisphere) to minimize the spread inward of

errors from the boundaries. Forecasts for 36 hours or longer appear to be better than conventional methods of forecasting the flow pattern at the 5-km level, especially for the longer time periods, where ordinary extrapolation methods break down.

2. The 2-parameter model, surprisingly, seems to give very little improvement, if any, at the 5-km level over the results obtained from the barotropic model. 36-hr forecasts for the surface flow patterns obtained from the 2-parameter model over the United States are not yet as good as those obtained by conventional methods, although there are some indications that the numerical method does better over the Atlantic and western Europe.

3. There are quite definite indications that the geostrophic approximation introduces certain typical errors, especially when the wind speed is high and the wave lengths of the flow patterns are short. These errors are perhaps one reason why the 2-level model gives no obvious improvement in the 5-km forecasts over those obtained with the barotropic model.

Current research on improving the accuracy of the short range (1-2 day) numerical forecasts is concerned first of all with improving on the geostrophic approximation, and secondly with the introduction of the effect of the heat added to the air when water vapor condenses. Two basic approaches are being employed for the former goal. One is to approximate the horizontal wind field by a stream function instead of by the pressure field (37, 39, 41), while the other approach is to return to the original equations of motion and retain only the hydrostatic assumption (38). The stream-function approach has proved very useful in the barotropic model, and has already been introduced into operational practice, However, it becomes difficult to use in more complicated models, and it may be that a return to the original equations will be necessary.

The release of latent heat is probably the most intense form of Q which occurs on a large scale, one inch of rain sufficing to heat the entire tropospheric air column by about 8 C. Several exploratory attempts have been made to include this phenomenon in the short-range forecast scheme, and the numerical prediction of large-scale cyclonic rain (as contrasted with small-scale showers) seems to be quite possible in the near future.

THE PROBLEM OF LONGER-RANGE FORECASTS

Extension of the techniques of dynamic prediction to periods longer than 2 or 3 days has not yet been seriously attempted. The nonlinear interactions implicit in the forecast equations now become very important (this is undoubtedly why conventional methods break down), as do the cumulative effects of friction and nonadiabatic heating. One might hope to develop a theory which applied only to changes occuring over, say, a week or more, much as the geostrophic theory is applicable only to time scales of several days. However, the development of such a theory would seem necessarily to be even more difficult than conventional turbulence theory, and the tendency of most workers in the field would probably be to aim rather at a gradual refining of the techniques now used for short-range forecasts, so that they can be carried farther into the future.

Of the difficulties listed in an earlier section, *b*, *c*, and *e* are essentially technical difficulties which should become less serious as computing machines (and our skill in using them) become more powerful. Problems *a* and *d*, however, will remain. It is known, for example, that relatively innocuous looking differences in initial analyses over the Atlantic Ocean (differences which are completely compatible with the sparse observational network) can lead to very different forecasts even 2 or 3 days later, and the problem over the Pacific Ocean and the southern hemisphere is undoubtedly even more critical in this respect (53). A scheme of bolstering the initial analysis with data from the previous *forecast* will certainly help this problem but the observational gaps over the oceanic areas will still have to be greatly reduced before any hope can be entertained of making useful long-range forecasts. Oceanic observations are relatively expensive, and therefore considerable thought must be given to evaluating the improvement in the forecast which can be expected from additional data, and comparing the economic value of this improvement with the cost of the new observations. The first aspect of this problem has recently been treated by Thompson (57).

The formulation of the nonconservative effects ($\mathbf{F}$ and Q) also becomes more critical in the longer-range forecasts. Although laboratory experiments with heated rotating fluids (58) and some recent numerical experiments (34) both seem to suggest that the *general* character of the atmospheric motions does not depend critically on the detailed form of $\mathbf{F}$ and Q, the long-range forecasting of *deviations* from the climatic normal is probably a quite different matter, requiring considerable care in the treatment of both $\mathbf{F}$ and Q.

NUMERICAL INTEGRATION AND THE EXPLANATION OF CHARACTERISTIC FEATURES OF THE ATMOSPHERE

The problem of explaining the "general circulation" of the atmosphere (that is to say, the statistical properties of the large-scale atmospheric motions) has always interested meteorologists, and the development of numerical prediction techniques has now made it possible to attack this problem too in a quantitative manner. The lack of sufficient initial data which at the moment hampers the accurate prediction of real weather situations is not so much of an obstacle here, since the results to be obtained have only statistical significance, and presumably depend primarily on the external parameters (such as the distribution of insolation, land, sea, etc.). Instead, the problem is rather to choose suitable forms of the equations and boundary conditions such that their numerical solution will illustrate certain aspects of atmospheric behavior without being so general that it is impossible to separate the effects of various parameters on the resulting flow patterns. A recent numerical experiment along these lines by one of the writers was partially successful in explaining the observed distribution of mean zonal wind (34), and further research in this direction seems very promising. For many purposes, a representation of the motion in wave-number space rather than in actual space avoids some of the difficulties inherent in a simple finite-difference representation, and will probably be very useful in numerical experiments of this type (49).

Similar numerical experiments may also be conducted to study the mechanism and formation of smaller-scale phenomena such as hurricanes, tornados, and convection in clouds. Although actual laboratory experiments may be very useful in such work, it is generally impossible to satisfy all the modeling criteria. Numerical experiments then provide an extremely valuable complement to the study of meteorological phenomena by the conventional means of observations, analytical theory, and physical experiment.

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"Letters to the Editor" and "Books Received for Review" appear after the reviews

Theoretical and Experimental Methods

(See also Revs. 2024, 2029, 2062, 2072, 2096, 2171, 2172, 2186, 2192, 2236, 2277, 2290)

Book—1999. Richards, R. K., Arithmetic operations in digital computers, D. van Nostrand Co., Inc., 1956, iv + 397 pp. $8.

Many papers relating to the mechanization of digital computation have appeared in the periodicals, but the development of this field in the past decade has been so rapid that it has frequently outstripped the rate at which knowledge and experience could be consolidated in book form. Hence the appearance of this book which, in the terms of the preface, purports to answer the question "How does a digital computer work"? is most welcome.

Of course not every facet of the subject could be covered in a book of this size. Thus while the functions of the basic elements that comprise a modern high-speed automatic digital computer are described, the details of the operation and design of these elements are not discussed. Instead, the objective is to explain how the basic elements are arranged to perform the desired arithmetical operations. This is primarily what has become known as the "logical" design of the computer and an excellent account of the present state of the art is given.

Number systems and how they lend themselves to physical interpretation are discussed. Boolean algebra and its application to the design of networks that effect prescribed logical relationships are elucidated. Techniques that can and have been employed to achieve addition, subtraction, multiplication and division, both binary and decimal, are described in considerable detail. Some attention is given to other operations commonly performed by these computers; and going beyond the discussion of the arithmetical unit, an explanation is given of the interrelationship of all of the components that are required for a complete computer and how the various units are controlled to function in harmony. Finally, general principles of programming, that is, instructing the computer to perform a desired sequence of operation, are illustrated by the example of a hypothetical "specimen" machine.

To those to whom arithmetic in any form is far from appealing, and even perhaps to those who find the mechanization of digital computation a most fascinating subject, the details of arithmetical operations are likely to become rather tedious. The author holds the reader's attention as well as could be expected with material of the kind and is to be commended particularly for his remarkably lucid treatment of matters that are involved and intrinsically awkward to explain. This is not to say that there are not passages that bear some rereading, but there are few, if any, sections that require prolonged study.

In a field so new, it is to be expected that there would be some questions unsettled and open to controversy. It is felt that the author does well in handling such questions by simply stating the pros and cons as they appear in the light of present experience and thought.

The book is suitable for use as a text and is also a useful reference for those working in the field. L. Pode, USA

2000. Brown, J. H., Carr, J. W., III, Larrowe, B., and McReynolds, J. R., Prevention of propagation of machine errors in long problems, *J. Assn. Comp. Machy.* **3**, 4, 348–354, Oct. 1956.

This article describes an integrated checking procedure used with MIDAC, the University of Michigan Digital Automatic Computer, in the solution of a long complex problem. The procedure is called the Large Program System (LPS), and includes automatic recording of the volatile storage contents at regular intervals, programmed summing checks of memory transfers, and optional paper-tape roll-back procedures. General aspects of the system are discussed, along with a description of some operating experience. L. D. Findley, USA

2001. Schecher, H., Methods for the simplification of programming of electronic digital computors (in German), *ZAMM* **36**, 9/10, 377–395, Sept./Oct. 1956.

Paper deals with general question of simplifying programming by

auto-coding schemes. Examples are given of iterative routines involving address substitution. Incorporation of special facilities for program control may result in worthwhile saving of both programming and computing time. Progress toward completely "floating" program without addresses is envisaged.

N. Ream, England

Book—2002. Johnson, C. L., Analog computer techniques, New York, McGraw-Hill Book Co., Inc., 1956, xi + 264 pp. $6.

Text, intended for classroom use but equally usable by the engineer or physicist in practice, is devoted to the theory, construction, and applications of electronic differential analyzers. A brief introduction, followed by chapters on linear computer components and time- and amplitude-scale factors, leads into consideration of set-ups simulating simple servomechanism systems and transfer functions exemplicative of solution of linear differential equations with constant coefficients. Successive chapters on multiplying and resolving servos, on generating functions internally and on associated computer instability analysis, on representing nonlinear elements, and on multipliers and function generators, encompass the basic techniques underlying solution of systems characterized by ordinary differential equations enfolding forcing functions and simple nonlinear phenomena. Some other applications are considered, such as solution of simultaneous algebraic equations, of eigenvalue problems characterized by separable partial differential equations or by simple finite-difference solution, and of polynomial equations.

Chapters on analog computer components (stabilized d-c amplifiers; overload-warning, operate-reset and potentiometer-setting systems; and automatic programming), on the complete and partial checking of computer results, on special aspects of high-speed repetitive-type computers as illustrated by Philbrick equipment, and on concise account of the digital integrating differential analyzer, complete the main text. A short preface, an appendix encompassing concise account of the solution of ordinary constant-coefficient linear differential equations by conventional and classical-D (though p is used) operator analysis and of Routh's criterion, and a subject index round out the book.

The context is lucidly written; the descriptive content is amply supported by well-detailed circuit diagrams and illustrations of commercially available equipments; and the theoretical content is generally accurate in statement and of such analytic level as to be easily understood by anyone having a knowledge of the elements of algebra, trigonometry, and calculus. These merits and the above-remarked scope and content enable reviewer to recommend this book to the earnest attention of all who desire a well-written introduction to the basic aspects of present-day electronic analog computing equipments.

In conclusion, it is to be noted that, despite the inclusive title, analog solutions by such commonly employed electroanalogic procedures as resistor and impedor networks, electrolytic tanks, conducting-papers, a-c electromechanical differential analyzers and integraphs, and yet other procedures encompassed in reviewer's series of articles on electroanalogic solutions [see AMR **9**, pp. 1-4, 49-55; AMR **10**, pp. 49-54] are not encompassed in Johnson's book. Accordingly, a user of this latter work may wish to round out his knowledge of modern electroanalogic procedures by reference to these articles (reprints available on request to Director of Engineering Experiment Station, University of Wisconsin, Madison, Wisconsin) and to the concise accounts of such procedures in Soroka's (1954) book, "Analog methods in computation and simulation," AMR **8**, Rev. 1537.

T. J. Higgins, USA

Book—2003. Doetsch, G., Handbook of Laplace transformation (Application of the Laplace transformation, Vol. III) [Handbuch der Laplace-transformation. Anwendungen der Laplace-transformation], Basel, Birkhauser Verlag, 1956, 300 pp. DM. 40.

Author states in Preface that the third volume forms a unit with the second volume and treats further theory and applications of the Laplace transformation. The parts of the present volume are numbered consecutively to those of volume two. Volume three consists of four parts, additional material to volume one, literary and historical references, a list of books on Laplace transformation, bibliography, index and corrections to volume two.

Part four (the first one in the third volume) treats partial differential equations: Their integration by means of Laplace transformation, partial differential equations with constant and with variable coefficients, compatibility conditions for the initial values, the Huygens' principle and Eulers' principle. Part five deals with differential equations; Ordinary differential equations in the original space (Originalraum) and in the image space (Bildraum) and two examples of partial differential equations. Part six contains integral equations and integral relationships: Integral equations of real convolution type in finite interval, integral equations of real convolution type in infinite interval, functional relationships with real convolution integrals, integral equations of complex convolution type, correspondence between complex convolution integrals of image functions and products of their original functions, and various integral equations which can be solved by Laplace transformation. Part seven deals with functions of exponential type and finite Laplace transformation.

P. Torda, USA

2004. Papoulis, A., A new method of inversion of the Laplace transform, *Quart. appl Math.* **14**, 4, 405-414, Jan. 1957.

Author's method takes advantage of the fact that the Laplace transform $f(p)$ is uniquely determined in terms of its values on an infinite sequence of equidistant points p_k along the real p-axis. The inversion is shown to be

$$F(t) = \Sigma\, C_k \phi_k(t), \quad k = 0, 1, 2, \ldots.$$

where the functions $\phi_k(t)$ are a known complete orthogonal set (the trigonometric, Legendre, and Laguerre are employed in the paper), and the constants C_k are determined from the values $f(p_k)$.

Author shows the stated inversion $F(t)$ results from employing a suitable transformation (depending on set ϕ_k to be used) to the integral definition

$$f(p) = \int_0^\infty e^{-pt} F(t)\, dt$$

and evaluating the C_k's through the orthogonality of the ϕ_k set. Two simple examples are treated and compared with known inversions. Agreement is good. J. Miklowitz, USA

2005. Diaz, J. B., and Ludford, G. S. S., On the integration methods of Bergman and Le Roux, *Quart. appl. Math.* **14**, 4, 428-432 (Notes), Jan. 1957.

A previous note [AMR **8**, Rev. 2209] gives a correspondence between the representations (obtained by the methods of the present title) of the solutions of the linear hyperbolic differential equation. This correspondence has a disadvantage in that in certain cases singular functions may arise. The present note gives a second correspondence which avoids this difficulty. The paper concludes with an example from compressible flow. J. D. Riley, USA

2006. Collatz, L., Approximation of functions of one and several independent variables (in German), *ZAMM* **36**, 5/6, 198-211, May/June 1956.

Tchebysheff's problem—that is, the problem of minimizing the maximum error encountered in approximating a function by a linear combination of a finite number of given functions—is attacked here for case of functions of several variables. Certain theorems are derived which make possible a relatively simple calculation of

upper and lower bounds on the minimax of error obtainable with a given set of functions. A method is developed for the approximate solution of boundary-value problem involving a second-order partial differential equation, permitting a calculation of error as well as of the unknown function. A. Leitner, USA

2007. Svirskii, I. V., Construction of a variational method for calculations (in Russian), *Prikl. Mat. Mekh.* **19**, 4, 453–462, July/Aug. 1955.

Variational methods are often used when the character of the solution is known. It appears that a small change in the approximately estimated starting solution does not appreciably change the result. This great advantage follows from the fact that the variational methods exploit the condition of vanishing of the first variation, so that the value of the integral varies slowly in the neighborhood of the solution.

Author describes how to construct, for a given differential equation, such variational problems as are distinguished by the following claim: the deviation from the solution influences as little as possible the deviation of the result.

Author explains the described method in two examples which sufficiently illustrate the application of the procedure both in boundary and in eigen-value problems.

K. Julis, Czechoslovakia

2008. Chao, C.-C., The closed-form summation of some common Fourier series, *Quart. J. Mech. appl. Math.* **9**, 4, 508–512, Dec. 1956.

A method is presented for obtaining closed form summation of Fourier series of the types

$$f(x) = \sum_{i=1}^{\infty} \frac{i P(i^2)}{Q(i^2)} \sin\left(\frac{i\pi x}{L}\right)$$

and

$$f(x) = \sum_{i=1}^{\infty} \frac{P(i^2)}{Q(i^2)} \cos\left(\frac{i\pi x}{L}\right) + \text{constant}$$

where $P(i^2)$ and $Q(i^2)$ are polynomials.

The result is obtained as the solution of a linear ordinary differential equation with constant coefficients. The method is novel in that it is simple and depends only on elementary concepts, but it is applicable only to the rather narrow class of series given above. C. T. West, USA

2009. Axpeitia, A. G., On systems of linear equations and the simplex method, Brown Univ., Div. appl. Math. IBM–12, 17 pp., Apr. 1956.

The problem of construction of a nonnegative solution of a system of linear equations, considered by the author, contributes to ease of applying the simplex technique to practical problems.

As a particular case of the first problem, maximization of a linear function of variables, subject to linear inequalities, is considered; the analogy between the problem of the feasible solutions and the general problem of linear programming is shown.

Theorems advanced show that, in practical cases, computation of coordinates may be avoided. Z. W. Dybczak, Canada

2010. Bottema, O., The Routh-Hurwitz condition for the biquadratic equation, *Indagationes Math.* **18**, 4, 403–406, 1956.

The elementary derivation for the stability criterion for a quartic [see, for example, J. P. Den Hartog "Mechanical vibrations," 4th ed., McGraw-Hill, N. Y., p. 288] is repeated. A curious discontinuity is noted for the special case in which the coefficients of the odd powers in the quartic are zero. A geometrical diagram explains the paradox. S. H. Crandall, USA

2011. Bottema, O., On the roots of the biquadratic equation, *Indagationes Math.* **18**, 4, 407–410, 1956.

The general quartic from which the x^3 term has been removed has three independent coefficients. Author shows how a two-dimensional diagram can be used to determine the nature of the roots: four real roots, two real and a pair of complex conjugates, or two pairs of complex conjugates. S. H. Crandall, USA

2012. Bashkow, T. R., and Desser, C. A., A network proof of a theorem on Hurwitz polynomials and its generalization, *Quart. appl. Math.* **14**, 4 423–426 (Notes), Jan. 1957.

It is shown that any general synthesis procedure of networks leads to a canonical representation of a Hurwitz polynomial and that any Hurwitz polynomial can be synthetized as the transfer impedance of a lossless network operating between two one-ohm resistors. G. Kron, USA

2013. Wood, S., A problem in selecting random numbers—the design principles of "Ernie," *Operat. Res. Quart.* **7**, 4, 107–110, Dec. 1956.

Book—2014. Lanczos, C., Applied analysis, New York, Prentice-Hall, Inc., 1956, xx + 539 pp. $9.

This is a valuable tome. The preface and introduction contain remarks of historical and philosophic interest. There is a discussion of the terms pure and applied mathematics, numerical analysis, and a newly coined term, "parexic" analysis. A pure analyst is one who works in purely theoretical constructions while a numerical analyst translates the processes of analysis into machine operations. There is a large gap between these two concepts. It is recognized that applied mathematics ultimately reduces to numerical data, and the replacement of infinite by finite processes introduces an error. The study of finite algorithms (parexic analysis) is not only of practical interest, but of scientific interest as well. Granted that an error occurs, the question is how to theoretically design algorithms to approximate the solution of an analytical problem. The idea is to minimize the error in a small number of steps, and to estimate the error with sufficient accuracy. This is the dominant theme of the volume. Application of orthogonal polynomials, especially those of Chebyshev, are central to the argument.

There are seven chapters. The first treats solution of algebraic equations. This is perhaps the weakest chapter of the volume. The iterative methods of Lin, Aitken, and their extensions are not considered. Matrixes, eigen value problems, and solution of large-scale linear systems is taken up in chap. VI. Harmonic analysis is the subject of chap. IV. Here one finds a wealth of material. Topics treated are trigonometric interpolation, Fourier transforms and integrals, Laplace transforms, inversion of Laplace transforms, etc. Chapter V studies the problem of data smoothing, differentiation, and interpolation, while quadrature methods are considered in chap. VI. The final chapter deals with power series expansions, both convergent and asymptotic, and their economization using the r-method. There is a useful appendix of 14 tables. A selected general bibliography of books is provided, and additional references are given at the end of each chapter. Many important references are omitted.

The volume is flavored with numerous examples. Many of the developments are only sketched, and filling in of details is left to the reader—an excellent idea. In a number of instances this additional effort should provide stimulus for further research.

Y. L. Luke, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2162, 2187, 2251)

2015. Nevesnov, V. I., The inverse problem in the dynamics of

machines (in Russian), *Nauch. trudi Odessk. in-ta inzh. mor. flota Jubilee number*, 12–20, 1955; Rev. no. 1329, *Ref. Zh. Mekh.* 1956.

The problem is examined of the determination of the forces acting on a mechanical system with a predetermined law of motion.

For the solution of this problem, author suggests representing the functions of the reduced moments of the moving forces, the useful reaction forces, frictional forces, and derived moment of inertia, in the form of exponential or trigonometric polynominals. The solution is reduced to determination of the coefficients of expansion of the said functions.

An example of a solution in the general form is given.

Courtesy of Referativnyi Zhurnal V. A. Zinov'ev, USSR
Translation, courtesy Ministry of Supply, England

2016. Rumiantsev, V. V., Equations for the motion of a solid with a liquid-filled cavity (in Russian), *Prikl. Mat. Mekh.* **19**, 1, 3-12, 1955.

Using a fixed Cartesian coordinate system and one moving with the body, author first discusses the kinematic characteristics and virtual displacements of a mechanical system, consisting of a rigid body in which a cavity is partly or totally filled with an ideal incompressible fluid. Expressing the kinetic energy through coordinates and kinematic characteristics, author derives the dynamic equations from an expression of Hamilton's principle of least action, which was established by him earlier. From relations for the structural constants of the group of virtual displacements can be deduced that the equations of motion of the body are identical to those established by the author earlier [title source **18**, 6, 1954]. The same procedure is then applied to the problem, assuming that the second coordinate system is in translatory motion with the center of mass of the body. Using the first set of coordinates the canonical equations of motion of the system in a form due to N. G. Chetaev [title source **5**, 2, p. 253, 1941] are also derived.

A. Kuhelj, Yugoslavia

2017. Williams, D., and Rae, S. C., The flexural axis of thin-walled sections that have no plane of symmetry, *Aero. Res. Counc. Lond. Rep. Mem.* 2939, 6 pp., 1955.

A method of finding the flexural axis of unsymmetrical thin-walled sections is described that not only obviates the necessity for first finding the principal axes of inertia, but also simplifies the whole procedure. From authors' summary

2018. Scott, G. D., Precession of a gyro and model of a gyro-compass, *Amer. J. Phys.* **25**, 2, 80–82, Feb. 1957.

Two aids to the teaching of gyroscopic motion are given: (1) the precession of a gyro is discussed as a rotational analogy to the case of a stone whirling on the end of a string; (2) precession is explained qualitatively in terms of linear dynamics. As an example of precession a north-seeking gyro-compass is considered and a model described which illustrates its behavior.

From author's summary

2019. International conference on gears (in French), *Rev. univ. Min.* (9), **99**, 9, 241–404, Sept. 1956.

Report of Liege Institution of Engineers' three-day conference on gears, Liege, May 1956. One-third of material is devoted to the spiral bevel gear systems of four manufacturers of cutting machines. Systems expounded are Gleason, Klingelnberg (hobbed "Palloid"), Oerlikon ("Eloid"), and Heidenreich and Harbeck.

Paper on spur gear tolerances gives current proposals by the International Standaridization Committee ISO TC 60 Working Party. Paper on measurement of hobbing machine errors is reprint of Timms, Mécanique Industrielle (Paris) July 55. Papers on materials and heat-treatment, generally expository without novelty, cover choice of materials (Mossoux), heat treatment generally (Progneaux), induction-hardening (Partiot) and flame-hardening (Cronegress, also reprinted from Mecanique Industrielle, Apr. 1955). Purdy on "Basic causes of gear failure" is good general review for nonspecialists. In addition to ISO TC 60 proposals for tolerances, another paper by Henriot covers proposed ISO TC 60 correction system addendum increment $x = 0.03\ (30 - n)$ where n is number of teeth, compares this with three other continental proposals in respect of contact ratio, specific sliding, surface stress and bending strength, concludes that ISO proposal is marginally best overall. Capelle's paper on "L'Engrenage, Difficile Synthèse", which may be translated "The art of gear design", treats the following: (1) Efficiency of spur gear teeth on assumption of constant friction coefficient and equal load distribution when two tooth pairs are in contact; (2) gears with equal specific sliding as pairs of maximum efficiency; (3) effect on load distribution between pairs of (a) inaccuracies, (b) surface compression, and (c) deflection: surface compression stated to be relatively negligible, as is generally agreed. Finally, there is a paper by Deby on the need for more understanding of gear technology in design offices, and one by Chalvet on the evolution of splined shafts.

Conference appears to have been a worthwhile "get-together", but papers contain little of interest to those familiar with literature in English or German. E. M'Ewen, England

2020. Mewes, E., Formulas expressing forces of inertia and kinematic relations for excentred crank mechanism (in German), *Ing. Arch.* **24**, 5, 291–298, 1956.

2021. Martarelli, G., The contact between wheel and rail (in Italian), *Pubbl. Fac. Ing., Univ. Pisa* **15**, no. 748, 19 pp.

The title study examines the nature of the rolling surface between track and wheel, which affects the smoothness of the motion of the vehicle and the stability of the wheel. This survey, both from the theoretical and practical point of view, concerns not only the new, but the altered-by-use profiles.

It is known that, under normal conditions, the horizontal component of the force acting at the point of contact between track and wheel and the perpendicular component at the guiding point (point of contact between wheel nail and track) are negligible. With time, however, because of change in the shape of the rolling surfaces of the wheel and track, due to wear, this situation can be reversed. This results in an irregular motion and an unstable wheel.

The author gives, at the beginning, the relationship between the different track, wheel, and vehicle elements and ends with formulas, which determine the guiding point, as well as its radius in the special case where $\Delta\theta = 0$ and also in the general case where $\Delta\theta \neq 0$. Then he gives the equation of the guiding curve and calculates limiting values of the deviations $\Delta\theta$ as well as those corresponding to the contact point between wheel rail and track radius.

The survey is original and of considerable value. It contributes decisively to the solution of the problem of proper shape of the rolling surface between track and wheel so that a smooth and uniform vehicle motion can be obtained.

C. Papaioannou, Greece

2022. Rubenstein, C., A general theory of the surface friction of solids, *Proc. phys. Soc. Lond (B)* **69**, 441, 921–933, Sept. 1956.

A theory is developed giving the equation: $(Friction\ force) = C(Normal\ force)^{\beta}$ where C depends on the properties of the materials, the surface roughness, and on the apparent area of contact; and β depends only on the properties of the materials. Theory assumes adhesion theory of friction is valid and asperities deform at contact points according to stress $= K(strain)^{x}$ where K and x are constant. Theory is applied to experimental results of other investigations using both metals and nonmetals such as natural and synthetic fibers.

W. B. Stiles, USA

2023. Spurr, R. T., The "ploughing" contribution to friction, *Brit. J. appl. Phys.* **7,** 7, 260–261, July 1956.

When a hard surface is slid over a softer surface, part of the frictional resistance is due to the force required to plough asperities of the harder surface through the softer. It is shown how this ploughing contribution to friction can be obtained for hard steel balls and wedges sliding on soft metals.

From author's summary

Servomechanisms, Governors, Gyroscopics

(See also Rev. 2148)

2024. Ku, Y. H., The phase-space method for analysis of nonlinear control systems, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-103, 7 pp.

The n^{th}-order differential equations arising are reduced to a set of n first-order equations. A finite difference scheme for solving these is indicated.

C. Ablow, USA

2025. Lehnigk, S., The Nyquist criterion (in German), *Regelungstech.* **4,** 8, 195–197, 1956.

The Nyquist frequency response criterion is reduced to its basis. Proof is obtained by means of a conformal mapping. Two facts emerge: (1) The Nyquist criterion is valid for every control loop (no matter how branched). (2) The open loop does not have to be stable to permit conclusions regarding the stability of the closed loop by means of the frequency response locus.

From author's summary

2026. Michels, A., and Ritzke, D., Method for improving sensitivity and stability of an on-off temperature control, *Appl. sci. Res.* (B) **6,** 3, 137–143, Dec. 1956.

General design principles of temperature-regulating devices employing on-off control are discussed. The usual inverse relationship between sensitivity and stability against outside influences can be improved by automatic variation of the input potential at the terminals of the control heaters. A device is described in which the temperature-sensing element actuates the on-off switch, while a clock mechanism measuring the length of the heating and cooling cycles controls the power into the heaters.

From authors' summary by I. Flugge-Lotz, USA

2027. Bass, R. W., Improved on-off missile stabilization, *Jet Propulsion* **26,** 8, 644–648, 643, Aug. 1956.

A new synthesis procedure for on-off control systems is presented, by means of which the delays due to time-lag and hysteresis in the system can be completely eliminated. This is readily effected by adding feedback from the off-on element itself to the conventional error and error-derivative feedbacks. By generalization (to inhomogeneous piecewise linear difference-differential equations) of the functional relationship $E(t + s) = E(t)E(s)$ (which is satisfied by any fundamental matrix of solutions of a system of homogeneous linear differential equations with constant coefficients), an explicit algorithm is developed, according to which the ideal feedback coefficients of a "perfectly" stabilized servosystem can be read off directly from the equations of the corresponding conventional system. The use of this algorithm is illustrated by application to three second-order systems, and one third-order system, of one degree of freedom; and to one second-order system with three degrees of freedom.

The results are applied to several specific relay servomechanisms and missile control systems. It is shown that hunting can be eliminated without the introduction of chattering, and that systems thus stabilized can be optimized by the addition of a switching computer, but without the necessity of dual mode control. It is assumed without proof that, once the delays are eliminated, the resultant "ideal" system will be stable. In the examples given, this is known to be true, but the standard proofs are rather laborious.

From author's summary

2028. Nadzhafov, E. M., Abdullaev, A. A., and Krementula, Yu. V., Experimental investigation of natural vibrations in the internal circuits of pneumatic regulators (in Russian), *Avtomatika i Telemekhanika* **16,** 1, 27–42, 1955.

Authors describe the method and results of experimental investigations of the pneumatic regulator type 04 "*Tizpriber*" with internal contour consisting of two "valve-clapet" pneumatic relays coupled by inverse coupling.

The influences of the hydraulic resistance and the capacitance of the coupling on the frequency and amplitude of the natural vibrations are shown. The resistance expands the region of the vibrations toward the side of the lower damping diapasons, but increases the amplitude and decreases the frequency. Increasing the capacitance of the coupling has the same influence as increasing the hydraulic resistance.

It is shown also that a regulator of this type can be used as a regulator with continuous action, or as a vibrating regulator, depending on the construction parameters and on the coupling of the input to the regulator.

D. Raskovic, Yugoslavia

2029. Frede, W., Arithmetical operations with pressured air (in German), *Feinwerktech.* **60,** 9, 327–332, Sept. 1956.

A number of devices are described, allowing simple arithmetical operations, such as addition, subtraction, multiplication, division and formation of exponential functions, by aid of pressured air, led in chambers with suitable membranes. Examples are given where and in what form such devices are used in control engineering.

A. I. van de Vooren, Holland

Vibrations, Balancing

(See also Revs. 2236, 2238, 2242, 2371)

2030. Kynch, G. J., The fundamental modes of vibration of uniform beams for medium wavelengths, *Brit. J. appl. Phys.* **8,** 2, 64–73, Feb. 1957.

Paper employs Rayleigh-Ritz procedure to study longitudinal and flexural vibrations of elastic beams and rods. Using simple expressions for displacements, author derives dispersion curves for cases in which the wave lengths are of the order of the lateral dimensions of the beam, or larger. Beams of circular, elliptical, and rectangular cross section are considered, and an extension of the method to nonuniform beams is indicated. Discussion of various modes of oscillation is extremely lucid and enlightening.

Paper is warmly recommended to all workers in the field.

H. N. Abramson, USA

2031. Chen, H. S. C., Vibrations of an end-loaded strip, *Brit. J. appl. Phys.* **7,** 12, 450–451, Dec. 1956.

Author solves the problem of an end-loaded strip vibrating in a vertical plane. The mass of the strip is neglected, but a corrected value of load mass can be used to correct strip mass and inertia effects. A first approximation of the shape of the deflection curve is obtained by solving a differential equation based on the condition of static equilibrium. It is pointed out that this curve comes out essentially the same whether corrected or uncorrected values of load mass are used, and that values obtained are closer to experimental values than are the calculated values of previous investigators. An expression for frequency of vibration is derived from the deflection curve using energy methods.

A. G. Sharp, USA

2032. Crandall, S. H., and Strang, W. G., An improvement of the Holzer table based on a suggestion of Rayleigh's, ASME Ann. Meet., New York, Nov. 1956, Pap. 56-A-27, 3 pp.

The improvement mentioned in the title is attributed to Rayleigh and to Kohn, and "...amounts to using the Holzer table to obtain the mode shape corresponding to a given frequency and then to obtain an improved frequency from this mode by equating the extreme values of kinetic and potential energies." It appears that, with proper care, the convergence of the Holzer scheme is markedly accelerated by the proposed method.

H. Deresiewicz, USA

2033. Pian, T. H. H., Structural damping of a simple built-up beam with riveted joints in bending, ASME Ann. Meet., New York, N. Y., Nov. 1956, Pap. 56-A-2, 4 pp.

Paper is a theoretical study of beam with damping due to screw-fastened spar caps. This development extends work of AMR **6**, Rev. 3660 by allowing somewhat stiff screws to prevent sliding motion between cap and beam. Results indicate that the energy loss per cycle is proportional to both load amplitude and tightness of joint for very large amplitude vibrations. Experimental confirmation is qualitative.

A. H. Hausrath, USA

2034. Volterra, E., Eigenvibrations of curved elastic bars according to the "Method of internal constraints," *Ing. Arch.* **24,** 317-329, 1956.

Paper is a sequel to a previous one in which general equations were developed [AMR **9**, Rev. 1700]. Present paper shows how solutions for curved bar can be found in terms of known solutions for straight bar.

D. C. Johnson, England

2035. Makarova, V. I., The determination of the modulus of elasticity in torsional vibration (in Russian), *Zavod. lab.*, **21**, 3, 354-355, 1955; Rev. no. 1784, *Ref. Zh. Mekh.* 1956.

2036. Prohl, M. A., A method for calculating vibration frequency and stress of a banded group of turbine buckets, ASME Ann. Meet., New York, N. Y., Nov. 1956, Pap. 56-A-116, 11 pp.

The complex structure caused by applying shroud bands to turbine buckets results in natural modes, not revealed by simple analysis, whose resonance with nozzle excitation has caused bucket failures. Author applies the Myklestad-Prohl method to this structure by treating the buckets as connected series of lumped springs and masses coupled at their ends by a flexible and extensible shroud. This yields the natural frequencies and modes, from which are found the resonant stress distributions for arbitrary stimulus distribution and over-all damping. Space-time phasing effects of nozzle disturbances are considered.

Prohl's results are directly applicable to nontwisted buckets for which wheel effects and flexure-torsion coupling in individual buckets may be neglected, (although coupled motions of the *group* are considered). These limitations could be removed by major extensions of the analysis and at the expense of greatly increased demands on the computer. A large digital computer is required in either case.

This is the first analysis of group vibration behavior of real buckets, in contrast to highly simplified mathematical models, and is capable of further extension to even more complex cases. The paper is of utmost importance to turbine bucket designers.

J. E. Corr, USA

2037. Hanson, M. P., A vibration damper for axial-flow compressor blading, *Proc. Soc. exp. Stress Anal.* **14,** 1, 155-162, 1956.

A method is presented of vibration suppression in axial-flow compressor blading involving centrifugally loaded pins that contact the blade and rotor. During vibration, the relative motions between the contacting surfaces introduce frictional forces and thereby establish damping in the blade system. The desired high damping is obtained by a suitable selection of pin materials, mechanical fit, and blade proportions. The results of the investigation indicate that with the use of the pin damper the vibratory stress of the test blade was reduced by a factor of ten. The damper remained effective after a total of 100 hr of operation regardless of severe frictional wear of the pin. Variation of the centrifugal loading had only a small effect on the resulting high damping.

From author's summary

2038. Birmingham, J. T., and McGoldrick, R. T., Vibration generator experiments on SS Gopher Mariner, *David W. Taylor Mod. Basin Rep.* 1011, 15 pp., Mar. 1956.

2039. Agopsowicz, T., Torsional vibrations in diesel-electric sets (in Polish), *Zesz. Nauk P. Gd.* **4,** *Mechanika* 1, 79-118, 1956.

Paper presents the first part of a larger whole. It contains general characteristics of two sets, supposed to work either separately or simultaneously, for the same electric lighting net. The problem consists in tuning these sets in a way to avoid the twinkling of the light. One of these sets is actually working; in the other the electric generator is to be adjusted for the existing diesel engine. Two kinds of vibrations appear: mechanical vibrations—in the form of torsional vibrations of the crankshaft—and electrical vibrations. Computation method of torsional vibrations of crankshafts of both sets is presented in detail, the degree of nonuniformity of speed being also determined. Comparison of free mechanical and electrical vibration frequencies is discussed.

J. Naleszkiewicz, Poland

2040. Kabachinsky, N. N., On the problem of calculating the natural transverse and torsional vibrations of gear wheel systems (in Russian), *Trudi Gorkovsk. politekhn. in-ta* **9,** 2, 4-9, 1954; Rev. no. 1337, *Ref. Zh. Mekh.* 1956.

The flexural-torsional vibrations of shafts and gear-wheels about their positions corresponding to constant mean torque values are investigated. It is assumed that each pinion oscillates with two degrees of freedom. All oscillatory deflections are assumed to be sinusoidal and synphasal. Equations are set up for determining the frequencies of oscillation, the solution of which is recommended by the iteration method. The satisfactory agreement between the calculated and the experimentally determined frequencies is confirmed.

S. G. Kislitsin, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2041. Mise, K., and Kunii, S., A theory for the forced vibrations of a railway bridge under the action of moving loads, *Quart. J. Mech. appl. Math.* **9,** 2, 195-206, June 1956.

In comparision with known solution given by Sir Charles Inglis, authors present a more precise solution of the problem of railway bridge vibration, caused by hammer blow effect of steam locomotives. The difference is caused by a new solution of the differential equation of dynamic equilibrium of forced vibrations for a given problem. They present the results of Sir Ch. Inglis measurements on Newark Dyke Bridge, and then give the results following from the new solution.

V. Mencl, Czechoslovakia

2042. Chilver, A. H., A note on the Mise-Kunii theory of bridge vibrations, *Quart. J. Mech. appl. Math.* **9,** 2, 207-211, June 1956.

A. H. Chilver analyses the differences of both methods (see preceding review) and points out that the difference is not in the critical speed of the locomotive but in the deflections, which are considerably greater when using the method of Mise and Kunii.

V. Mencl, Czechoslovakia

Wave Motion in Solids, Impact

(See also Rev. 2058)

2043. Thomas, T. Y., On the propagation of weak disconti-

nuities in perfectly plastic solids, *J. Math. Mech.* **6,** 1, 67–85, Jan. 1957.

Highly mathematical, abstract investigation, concerned with the conceptual structure of the theory rather than with applications. Author defines a weak discontinuity as a surface across which the field functions themselves are continuous, while some of their derivatives are not. The assumption of plane stress is made throughout. Both the von Mises and the Prandtl-Reuss equations are considered. The main results consist in certain algebraic relations between the propagation parameters of wave surfaces and the parameters of the stress field. Further results are certain theorems on the nature of the possible weak discontinuities. F. C. Roesler, England

2044. Lee, E. H., and Wang, A. J., Wave propagation in an elastic rod exhibiting internal Coulomb friction, considered as a model for a ring spring, *J. appl. Mech.* **23,** 3, 367–372, Sept. 1956.

The motion of a spring and the forces between conical surfaces in the case of a semi-infinite ring spring under a pulse of load at one end have been discussed by methods of plastic wave propagation in one dimension. Concentration of the absorption of the total input energy has been obtained in the region of the impact.
S. C. Das, Canada

2045. Chappelear, J. E., An investigation of the solitary wave, *Trans. Amer. geophys. Un.* **37,** 6, 726–734, Dec. 1956.

An approximate theoretical solution by Rayleigh and Boussinesq is extended to give the internal velocity distribution. A numerical iterative relaxation method is devised for improving the solution and the results so obtained give better agreement with the experimental results of Daily and Stephan.

The calculations illustrate the desirability, in reviewer's opinion, of preliminary conformal mapping of flow region onto a finite region, mentioned as a possibility by the author but not adopted. The method seems sufficiently laborious to demand the use of a fast electronic computer.

Reviewer would have preferred the presentation of results in dimensionless form, and notes the occurrence of several minor errors, especially in equations (24) and (25).
A. H. Armstrong, England

2046. Korenev, B. G., and Ruchimsky, M. N., Some problems of the dynamics of beams on an elastic support (in Russian), *Nauch. soobshch. Tsentr. n.-i. in-ta prom. sooruzheniy* no. 20, 44 pp., 1955; Rev. no. 1651, *Ref. Zh. Mekh.* 1956.

A number of problems are examined relating to the resistance of a beam of infinite length and a beam of finite length, supported on an elastic foundation. Formulas are given for the dynamic coefficients, considering the loaded masses and the damping. The problem of local impulse (momentum) action on the beam is examined. A. A. Popov, USSR
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2047. Riparbelli, C., On the relation among stress, strain, and strain rate in copper wires submitted to longitudinal impact, *Proc. Soc. exp. Stress Anal.* **14,** 1, 55–70, 1956.

Series of exploratory tensile impact tests on copper were made to investigate mechanism of plastic deformation. Results confirmed earlier observation that velocity of elastic wave is constant and independent of any plastic flow. Rate of plastic flow was found to approximate linear function of "excess of stress", the difference between dynamic stress and static stress for same plastic strain.
From author's summary by F. J. Mehringer, USA

2048. Gorten, G., Impact loads in gear trains, *Mach. Design* **29,** 5, 83–87, Mar. 1957.

2049. Leet, D., Use and abuse of earth waves, *Amer. Scient.* **45,** 2, 114–124, Mar. 1957.

Elasticity Theory

(See also Revs. 2022, 2067, 2073, 2082, 2086, 2114, 2126, 2159, 2161, 2235, 2323, 2324)

Book—2050. Seely, F. B., and Smith, J. O., Resistance of materials, 4th ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xvi + 459 pp. $6.50.

This revision of a well-known text represents distinct departure from the established pattern in Mechanics of Materials texts. On superficial examination this may not be evident, since in the main it looks like the type of text one is used to. Closer reading reveals a quite different philosophy, which is evidenced principally in the inclusion of inelastic behavior as an integral part of the subject. Reviewer feels this is in line with modern developments in the understanding and uses of materials. To the traditional treatment of relations between loads and stresses and between loads and deformations authors have added an essential third consideration, that of the effect of mechanical properties on the use of these relations in design, in both elastic and inelastic ranges.

Text is divided into two parts, as in previous editions. First part covers subjects usually included in elementary mechanics of materials courses; second part covers additional subjects that may be included in elementary or more advanced courses.

Chapter I introduces student to loads, internal forces, stresses, and strains from general point of view, including shear as well as normal stresses. Simple static uniaxial loads are treated next, but again shear is included since it is present on all oblique planes. The usual elastic problems are discussed: thermal stresses, members of two materials, thin-walled cylinders, and stress concentrations. This is followed by a thoroughgoing treatment of inelastic behavior in which considerable attention is given to effects of a definite yield point, as in the case of mild steel. Emphasis is placed on importance of safe *loads* as contrasted to stresses. Riveted and welded joints are given brief treatment appropriate for basic course. Chapter ends with discussions of safety factors and design of members.

Following chapters generally include same pattern: Introduction; elastic behavior; inelastic behavior; design of members.

Chapter II, on torsion, covers the usual elastic theory including shear flow in thin-walled tubes. Discussion of elastic shearing stress concentrations closes this part and leads naturally to inelastic behavior. Here the concept of fully plastic twisting moment is introduced and is used as one of the design criteria discussed in the closing articles of this chapter.

Chapter III begins the section on beams. Elastic behavior includes shear center which was formerly left as an additional topic of part II. In inelastic behavior the fully plastic theory is continued with derivation of fully plastic bending moment. In chap. IV deflection of beams is introduced. Solution of problems is by *moment-area* method exclusively. Two other methods—double integration and conjugate beam—are described in chapters in part II. Superposition is omitted entirely, apparently under the assumption that it belongs properly in design courses.

Chapter V is a short discussion of combined tension and bending, which is followed by columns in chap. VI. Here the importance of inelastic behavior is again apparent. Latest developments since Shanley's paradox are included.

Remaining chapters in part I are as follows: Chap. VII, Statically indeterminate members; Chap. VIII on combined stresses, and combined loads, including interaction curves for the inelastic case; Chap. IX on fatigue; and Chap. X, Dynamic loads

Part II includes topics covered in previous editions with fol-

lowing notable *omissions*: curved bars; flat plates; thick-walled cylinders and torsion of noncircular sections. These are presumably left for a more advanced text.

C. W. Richards, USA

2051. Wegner, U., Evaluation of boundary displacements in two-dimensional problems (in German), *ZAMM* **36,** 5/6, 192–198, May/June 1956.

Author shows that boundary displacements for disk-shaped bodies depend only on the determination of a potential function and not a bipotential function. A simple variational principle for the approximate computation of the necessary potential function is indicated and explained by a simple example.

E. G. Newman, USA

2052. Nowacki, W., Some boundary problems of the theory of elasticity (in Polish), *Arch. Mech. stos.* **7,** 4, 483–502, 1955.

Paper gives a general method of solving problems of the theory of elasticity concerning arbitrary systems subjected to surface forces, temperature changes, and initial stress. For the material (of an arbitrary type of anisotropy and inhomogenity) of the elastic body, the unique assumption is that of linear relation between stress and strain.

For an arbitrary elastic body, supported on the surfaces Ω and Φ, subjected to external load, body forces, initial stress, and thermal states, surface forces $X_i(Q)$, $i = 1, 2, 3$, appear on the surface Ω as functions of the point Q (1 determining the directions of the coordinate system). Assuming that $X_i(Q)$ are unknown functions, author reduces the problem to the investigation of the basic system, subjected to (a) the action of body forces, temperature changes, and initial stress in the case $X_i = 0$ and (b) that of the successive states $X_1(Q) = 1$, $X_2(Q) = 1$, $X_3(Q) = 1$.

Determing for the case of $X_i = 0$ the components $U_{i,o}(P)$ of strain at a point P of the surface and the components of strain at the same point for the successive cases $X_1(Q) = 1$, $X_2(Q) = 1$, $X_3(Q) = 1$, i.e. Green functions $U_{ki}(P, Q)$ in the basic system assumed, author expresses displacements of a point of the surface in an integral form.

For the determination of the unknown functions $X_i(Q)$, the boundary conditions at points Q' of the surface are used. This leads to a system of three Fredholm integral equations of the first kind with symmetrical kernels (in view of the reciprocal theorem for displacements):

$$U_k(Q^1) = U_{k0}(Q^1) + \int\int_{\Omega} \left[\sum_{i=1}^{i=3} X_i(Q)\, U_{ik}(Q^1 Q) \right] \delta\Omega = 0 \quad (k = 1, 2, 3).$$

This procedure is typical for the well-known "method of forces" in structural mechanics.

A procedure analogous to the "method of deformations" is described. Here a system of Fredholm integral equations of the first kind is equally obtained. Author emphasises considerable difficulties of determining the Green function in relation to the procedure called the "method of forces."

Systems of integral equations for some particular cases of elastic bodies (e.g., slices and plates with arbitrary boundary conditions, plates arbitrarily supported inside their spans) are presented.

The procedure given is of considerable generality; practical application, however, requires knowledge of Green functions for basic systems and solution of a system of Fredholm equations of the first kind. Author points out these difficulties.

W. Olszak, Poland

2053. Paria, G., A mixed boundary-valve problem of elasticity with parabolic boundary, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-24, 3 pp.

The problem of finding the stress distribution in a two-dimensional elastic body with parabolic boundary, subject to mixed boundary conditions, has been reduced to the solution of the non-homogeneous Hilbert problem following the method of complex variable. The result has been compared with that for a straight boundary.

From author's summary by E. Fliess, Argentina

2054. Ellington, J. P., On obtaining the shear stress-strain relationship from a hollow specimen in torsion, *J. roy. aero. Soc.* **60,** 552, 806–808 (Technical Notes), Dec. 1956.

To determine the shear stress-strain curve from a torque-twist diagram obtained with a hollow circular specimen, the scale factor relating these two curves must be established. For this purpose the mean diameter of the tube must be known. It is shown that taking as the mean diameter the arithmic mean of the outer and inner diameter of the cylinder is only allowed for diameter-thickness ratios in excess of 15–20. For smaller ratios, two possible formulas are derived by means of which the inaccuracies can be reduced.

R. G. Boiten, Holland

2055. Sternberg, E., and McDowell, E. L., On the steady-state thermoelastic problem for the half-space, *Quart. appl. Math.* **14,** 4, 381–398, Jan. 1957.

Authors consider the problem of steady-state thermal stress in the semi-infinite, elastic body under arbitrarily prescribed temperatures over a portion of the surface and uniform temperature over the remainder. They show that the problem reduces to the determination of Boussinesq's first logarithmic potential and establish a simple relation to the problem of the semi-infinite body under normal surface tractions. They are then able to use Love's results for the latter problem and so obtain solutions, in closed form, for uniform or hemispherical distributions of temperature over a circular area and uniform distribution over a rectangular area. An interesting result, among many in the paper, is that, regardless of the distribution of surface temperature, the stress in the body is always degenerate. Only the components parallel to the surface are non-vanishing.

R. D. Mindlin, USA

2056. Van Der Linden, C. A. M., Thermal stresses in a plate containing two circular holes of equal radius, the boundaries of which are kept at different temperatures, *Appl. sci. Res.* (*A*) **6,** 2/3, 117–128, 1056.

A steady state is considered when the boundaries of the holes are held at the temperatures T_0 and $-T_0$, respectively. The problem is of generalized plane stress. It is solved by introduction of "the potential of displacement" ψ, such that the x and y components of the displacements are ψ_x and ψ_y, and the Airy function in a known manner. Bipolar coordinates are employed.

A numerical analysis of special cases reveals quite interesting details. For instance, for holes with radii $r = 4.1$ cm, and 3.8 cm apart, and for the Poisson's ratio 0.3, the difference in temperature of 1°C on the boundaries of the holes produces maximum tangential stress of 4.4 kg/cm² and maximum shear stress of 8.9 kg/cm². Thus, "the thermal stresses can cause some complications even at moderate temperature differences."

The paper is an important contribution to the analysis of thermal stresses.

R. M. Evan-Iwanowski, USA

Experimental Stress Analysis

2057. Jessop, H. T., A tilting stage method for three-dimensional photoelastic investigations, *Brit. J. appl. Phys.* **8,** 1, 30–32, Jan. 1957.

Author describes method for finding the directions of the principal stress axes at any point in a three-dimensional photo-

elastic model. Thin slices cut from a frozen stress model are placed in a special universal tilting stage. The effects of rotations on the isoclinic fringes through the point are used to identify the principal axes. Successive adjustments of the stage are required to reach a solution. The procedure outlined is simpler than the former method based on the use of a von Fedorov-type tilting stage. W. Shelson, Canada

2058. Clark, A. B. J., Static and dynamic calibration of a photoelastic model material, CR-39, *Proc. Soc. exp. Stress Anal.* **14,** 1, 195–204, 1956.

A report of tests made to determine stress-optical and strain-optical coefficients for widely used CR 39 photoelastic material over the range of effective loading times from 10 minutes to 10^{-4} seconds. Dynamic calibration was obtained by striking a 1/2-in. square rod axially with a 0.30 cal. projectile, measuring strain with SR-4 gages and birefringence with a photocell. Modulus of elasticity was determined by measuring velocity of sound in the specimen. Results show strain-optical coefficient remains almost constant (decreases 7.5%) while modulus of elasticity increases 58% and stress-optical coefficient increases 42% as time of loading decreases from 600 to 10^{-4} sec. Author concludes that if Poisson's ratio can be considered constant, strain-optical coefficient should be constant also, and photoelastic results can be interpreted as strains. Proper value of modulus of elasticity is necessary to give stresses. No mention is made of temperatures at which tests were run. D. K. Wright, Jr., USA

2059. Vishnevetsky, Z. D., A polarization optical method of measuring stresses in full-scale structural elements (in Russian), *Zavod. Lab.* **21,** 4, 480–482, 1955; Rev. no. 1859, *Ref. Zh. Mekh.* 1956.

Author considers the method of stress analysis by optically acting transmitters distorted simultaneously with the surface of the element (optical strain gages), with which they are mechanically connected, has received insufficient practical application, for the following reasons: (1) Insufficient adhesion; (2) low optical activity of the material of the strain gage; (3) lack of specialized polariscopes satisfying the conditions of the experiment. To overcome these deficiencies, author suggests using: (a) Carbinol cement; (b) the optically highly active material IM 44 for the construction of the gages; (c) a polariscope constructed on the known principle of optical reflection with double path of the light rays.

This polariscope is described, and an account is given of the experimental determination of the coefficient of stress concentration of a relaxed metal rod, subjected to pure bending. It is not clear how the author has allowed for the margin (fringe) effect, known to be associated with the IM 40 material, as well as for the initial stresses set up by the carbinol cement for attaching the optically active material to the metal surface. For the experiments described by author, it would be possible to use one of the optically highly active, ethoxylene resins, which can be directly applied to the metal surface, have high adhesive power, and do not display any fringe effect.

Courtesy of Referativnyi Zhurnal S. P. Shikhobalov, USSR
Translation, courtesy Ministry of Supply, England

2060. Benito, C., Experimental scale model investigation of shell roofs (in French), *Publ. int. Assn. Bridge struct. Engng.* **16,** 35–38, 1956.

Rods, Beams, Cables, Machine Elements

(See also Revs. 2019, 2030, 2031, 2032, 2033, 2034, 2036, 2040, 2044, 2046, 2048, 2050, 2069, 2077, 2078, 2079, 2083, 2097, 2105, 2106, 2109, 2117, 2127, 2131, 2158, 2162)

2061. Archer, F. E., and Kitchen, E. M., Stresses in single-span deep beams, *Austral. J. appl. Sci.* **7,** 4, 314–326, Dec. 1956.

The stress distribution in deep beams of rectangular cross section and small thickness compared to the depth is determined in a direct manner by using strain-energy methods with the use of stress function. The stress function is taken in two parts: one part satisfies all the boundary conditions and the other is sum of products of a parameter and function, the latter part not affecting the boundary conditions. The parameters are found by the minimizing process. The first part of the stress function is found from boundary forces in the usual way with properly chosen multipliers.

Applications to specific problems are made and expressions for shearing force, bending moment, normal, and shearing stresses written. Taking depth to length of beam equal to unity and eleven parameters, calculations are made for longitudinal normal and shearing stresses. The results are shown by graphs and compared with results of Conway, Chow, and Morgan as well as with photoelastic method and the elementary theory. The agreement with Conway is good but, as expected, the results differ considerably from the elementary theory. The solution, in effect, is that obtained by the elementary theory plus the necessary modification.

No calculations were made for the transverse normal stress which becomes important as the depth-span ratio increases. It would have been instructive if authors had made such calculations.

S. Sergev, USA

2062. Seames, A. E., and Conway, H. D., A numerical procedure for calculating the large deflections of straight and curved beams, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-38, 6 pp.

Beam is divided into a number of small segments each of which is assumed to be bent into a circular arc by the average bending moment for the segment. Method is illustrated by numerical examples of straight and curved cantilever beams with concentrated and distributed loads and by the case of a circular ring subjected to diametrically opposed forces. For a straight cantilever with end load, a table with 14 columns is required to find the length of a beam with given angular deflection under the load. Several such tables would be required to solve the direct problem of finding the deflection for a beam of given length. It is claimed that method gives "excellent agreement" with other procedures.

S. H. Crandall, USA

2063. Abovian, G. A., The stress equation for the inner and outer flanges of a bent, double-tee beam (in Russian), *Sb. nauch. trudi Erevensk. politekh. in-ta* no. 9, 237–254, 1955; Rev. no. 1699, *Ref. Zh. Mekh.* 1956.

The radial normal stresses acting in the bending of a curved beam of double-tee section are investigated. In this case, the difference between the limiting stresses in the flanges of the double-tee may attain very high values. A method of equalizing these stresses is presented. Examples are given.

Courtesy of Referativnyi Zhurnal A. F. Rozhnyatovskii, USSR
Translation, courtesy Ministry of Supply, England

2064. Lazard, A., Breaking tests on beams reinforced with Torsteel 60 and 80 (in French), *Publ. int. Assn. Bridge struct. Engng.* **16,** 333–344, 1956.

2065. Kanushevich, E. S., On the calculation of a highly curved solid beam (in Russian), V. sb. Raschety na prochnost', zhestkost', ustoychivost' i kolebaniya, Moscow, Mashgiz, 110–130, 1955; Rev. no. 1700, *Ref. Zh. Mekh.* 1956.

A survey of existing methods, principally approximation methods, for determining stresses and strains in a curved solid beam.

Courtesy of Referativnyi Zhurnal V. V. Bolotin, USSR
Translation, courtesy Ministry of Supply, England

2066. Wahl, A. M., Stress distributions in rotating disks subjected to creep, including effects of variable thickness and temperature, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-162, 16 pp.

An analysis is made of the stress distribution during steady-state creep in rotating disks with central holes. Variables considered are the ratio of outer to inner diameter and various exponents n in the power law: $\epsilon = K\sigma^n \cdot f(t)$. The analysis shows that the difference between the peak and the average stress across the disk increases as the ratio of the outer to the inner diameter increases and as n decreases. It is also to be expected that the creep strain at the inner diameter is considerably higher than would be calculated on the basis of average stress values. It follows then that the rupture life would be shorter than expected on an average stress basis and that the decrease is greater as the material's strain at rupture becomes smaller.

Variations in thickness along the diameter do not materially alter the conclusions for a constant thickness disk providing that the thickness ratio is not greater than two. Of course, the average stress is lower and therefore the creep rate to be expected is lower.

Temperature gradients such as found in operation across the diameter serve to increase the creep strain at the inner diameter over that of a constant temperature disk and warrant close consideration.

No experimental results are given in this paper.

A. D. Schwope, USA

Plates, Disks, Shells, Membranes

(See also Revs. 2050, 2056, 2081, 2084, 2112)

2067. Higashi, Y., Bending of thin rectangular plates with any boundary conditions, *Mem. Fac. Technol. Tokyo Metrop. Univ.* no. 6, 45-77, 1956.

For six sets of boundary conditions author gives the Fourier series solution for the deflection of the plate with variable transverse load. However, for many practical problems the coefficients in the series solution must be obtained by some means from an infinite system of simultaneous equations.

B. E. Gatewood, USA

2068. Tarabasov, N. D., Determination of the stresses in an unrestricted plate with a rectilinear edge, near which compressed discs are situated (in Russian), Sb. Raschety na. prochnost', zhestkost', ustiochivost', i kolebanya, Moscow, Mashgiz, 103-109, 1955; Rev. no. 358, *Ref. Zh. Mekh.* 1956.

A stressed state is examined which occurs in an elastic plate (semi-surface $Im\ z > 0$) with m circular holes of radius r_n with centers at the points b_n, during the pressing into it of disks of radius $r_n + \delta_n$ made of the same material and having the same thickness as the plate. The problem may be reduced to the finding of two functions $\varphi(z)$ and $\psi(z)$ of the complex variable which are holomorphic in the semi-surface $Im\ z > 0$ and satisfying on the straight line $y = 0$ the condition

$$\varphi(t) + \overline{t\varphi'(t)} + \overline{\psi(t)} = \frac{E}{2}\sum_{n=1}^{m}\frac{\delta_n r_n}{\bar{t} - \bar{b}_n}$$

from it at once follows that

$$\varphi(z) = \frac{E}{2}\sum_{n=1}^{m}\frac{\delta_n r_n}{z - \bar{b}_n}\ ;\ \psi(z) = \frac{E}{2}\sum_{n=1}^{m}\frac{\delta_n r_n z}{(z - \bar{b}_n)^2}$$

The Muskhelishvili-Kolosov functions $\varphi_0(z)$, $\psi_0(z)$ in the region outside the S_0 hole are determined from the expressions

$$\varphi_0(z) = \varphi(z)\ ;\ \psi_0(z) = \psi(z) - \frac{E}{2}\sum_{n=1}^{m}\frac{\delta_n r_n}{(z - b_n)}$$

from which the stresses are calculated with the aid of known formulae. The numerical calculations are performed for the case of one disk pressed near the rectilinear edge of the plate. See also *R. Zh. Mekh.* 1955, 1458.

Courtesy of Referativnyi Zhurnal A. I. Lur'e, USSR
Translation, courtesy Ministry of Supply, England

2069. Tamate, O., The effect of a circular hole on the pure twist of an infinite strip, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-17, 7 pp.

Author uses the perturbation method to find the maximum deflections and moments in the plate. The strip is assumed to obey the Poisson-Kirchhoff theory of bending of thin plates.

B. E. Gatewood, USA

2070. Muster, D. F., and Sadowsky, M. A., Bending of a uniformly loaded semicircular plate simply supported around the curved edge and free along the diameter, *J. appl. Mech.* **23,** 3, 329-335, Sept. 1956.

Paper is of special interest to engineers engaged in turbine design. Using classical plate theory, authors employ standard residual problem technique to solve in series form the title problem. Authors must be commended for detailed numerical results, proof of the adaptability of solution to evaluation by electronic computers. Agreement with experimental results is good.

C. N. DeSilva, USA

2071. Kiselev, V. A., A method of initial parameters for calculating circular plates with an axially symmetrical load (in Russian), *Issled. po. teorii sooruzhenii* no. 6, 435-448, 1954; Rev. no. 380, *Ref. Zh. Mekh.* 1956.

The calculation of circular plates with an axially symmetrical load according to the method of initial parameters.

First of all a concentrated strip load, applied in a ring, is examined. Further, a case is taken of an annular load determined according to the parabolic law. Six examples are given of the calculation of complete circular plates, and also with a central hole, for various particular cases of loading, including concentrated moment loads. It is shown that this solution for a circular plate is based on the case of a concentrated strip load. Using this basic solution, it is possible to obtain solutions for other forms of load as well. Generalised equations for a circular and different and more simple method, were obtained by S. N. Sokolov in 1935 [*Tr. Mosk. in-ta. khim. mashinostt.* 1935, no. 1, 64-106].

Courtesy of Referativnyi Zhurnal S. S. Kryukovskii, USSR
Translation, courtesy of Ministry of Supply, England

2072. Lew, H. G., Fox, J. A., and Loo, T. T., Large deflection of curved plates, *NACA TN* 3684, 38 pp., Oct. 1956.

The specific problems treated are the deflections of doubly curved plates with normal edge loads, doubly curved plates under edge shear loads, and nearly cylindrical curved plates under longitudinal compression. The difference between the first two plates and the third one lies in the fact that the initial deflection is axially symmetric in the first two cases whereas the third plate is very close to a portion of a straight circular cylinder but has, in addition, a slight bulge along the length of it.

The principle of minimum potential energy, or equivalently the Ritz method, is used to determine the coefficients in the assumed expression for the stress function, and it is found that, for the initial deflections considered, only a few coefficients were

necessary to represent the complete solution. This is, of course, merely another way of saying that if the initial deflection can be represented well by a few terms in a double sine series and if the loads such that the total deflections under load are similar in form to the initial deflection, then only a few terms in a double sine series will suffice equally well to describe the deformed state.

In addition to the determination of the stresses and deflections, the effective widths of the curved plates were calculated for several cases and compared to flat sheets and circular cylindrical curved panels. Y.-H. Pao, USA

2073. Kempner, J., Sheng, J., and Pohle, F. V., Tables and curves for deformations and stresses in circular cylindrical shells under localized loadings, *J. aero. Sci.* **24,** 2, 119–129, Feb. 1957.

In earlier studies, authors obtained solutions of Donnell's equations for distributed line loads on a segment of a generator of a circular cylindrical elastic shell simply supported at ends. Present paper gives design graphs and numerical tables based on these results. Three cases are treated: (1) Uniform radial load distributed along a segment of a generator; (2) step-function-type load consisting of radial forces distributed over an interval of a generator, and the opposite forces distributed over an adjacent interval, thus providing the effect of a localized axial bending moment; (3) uniform circumferential moment extended over a segment of a generator. Data are tabulated for radius-thickness ratios from 10 to 1500 and radius-length ratios from 1/5 to 10.

Data permit determination of displacements, rotations, membrane stresses, and bending stresses in neighborhood of applied loads. It is shown that data may be used to approximate stresses caused by arbitrary surface loadings. H. L. Langhaar, USA

2074. Kornecki, A., A thin-walled toroidal shell under uniform pressure (in Polish), *Rozprawy Inz.* **4,** 1, 121–172, 1956.

A toroidal shell of circular cross section, bounded by two parallels and subjected to a uniform pressure, is considered. The problem reduces to one equation (with the corresponding boundary conditions), derived on the base of equilibrium and compatibility conditions by means of the "complex stress" method of V. V. Novozhilov.

The original part of the work is obtaining an approximate particular integral of the nonhomogeneous equation in a functional form, the auxiliary functions being expressed by means of Bessel functions.

Author establishes conditions to be satisfied by this integral, the form of which is obtained on the basis of the R. Clark and E. Reissner solution.

Adding the particular solution obtained to the general solution of the homogeneous problem obtained by E. F. Zenova and V. V. Novozhilov, author obtains the final solution of the problem under consideration in a functional form.

The degree of accuracy of this solution increases with decreasing shell thickness.

The calculation procedure is explained. Two numerical examples concern mechanical engineering problems.

Z. Parszewski, Poland

2075. Kirstein, A. F., and Wenk, E., Jr., Observations of snap-through action in thin cylindrical shells under external pressure, *Proc. Soc. exp. Stress Anal.* **14,** 1, 205–214, 1956.

L. H. Donnell, H. L. Langhaar, and A. P. Boresi had found by large-deflection theory that in hydrostatically loaded thin-walled cylinders there must exist postbuckling equilibrium with loads less than the initial buckling load, a gap of instability being between the two stable configurations. Paper gives experimental check of this. Using very thin shells of spring steel, loading can be carried out by evacuation, and strains remain within the elastic range, so that tests can be repeated with the same model. Strains are measured by strain gages. Pressure-strain curves with instability region and hysteresis, typical for snap-through phenomena, are obtained. Results are in fairly good agreement with theory. Experiments seem to have been carried out carefully.

E. Monch, Germany

2076. Nowacki, W., Some stability problems of cylindrical shells (in Polish), *Arch. Mech. stos.* **8,** 4, 705–724, 1956.

A cylindrical shell of constant thickness and constant curvature is subjected to the stresses σ_x, σ_y, and τ_{xy} which are known functions of x and y and act in the middle plane of the shell.

On the basis of W. Z. Vlasov engineer's theory of shells, the solution of the differential equation of the problem is obtained in the form of a surface integral. Using Green's transformation and assuming that the shell is either simply supported or clamped along the edges, the solution takes the form of Fredholm integral equation of the second kind.

In the case of free support of all edges of the shell, Green's function and the deflection surface are presented by means of a double trigonometrical series. The problem is thus reduced to the solution of an infinite system of homogeneous linear equations, which are identical to the system obtained by means of Ritz-Timoshenko energy method. The principal determinant of the system set equal to zero leads to an equation the roots of which are the critical values of the load.

The buckling condition for a cylindrical shell, clamped along all or some of the edges, and a shell reinforced with a rib is derived in the same way. Z. Kaczkowski, Poland

Buckling Problems

2077. Masur, E. F., and Milbradt, K. P., Collapse strength of redundant beams after lateral buckling, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-51, 6 pp.

According to classical linear theory, slender beams buckle laterally under vertical loads which remain constant as the buckling amplitude increases. Unless prior yielding takes place, the loads corresponding to neutral equilibrium represent the collapse strength of the beam. However, the inclusion of nonlinear terms in the strain-displacement relations modifies the predicted postbuckling behavior of redundant beams. If continued elasticity is postulated, increasing amplitudes are associated with increasing load magnitudes, which generally approach limiting values. These "ultimate loads" may be estimated by means of two principles establishing lower and upper bounds. Tests performed on a single-span beam of varying degrees of end restraint show good agreement with the proposed theory.

From authors' summary by J. W. Clark, USA

2078. Galkiewicz, T., Application of the perturbation method for the determination of the critical force of a compressed bar with a variable cross section (in Polish), *Zesz. Nauk PL* **10,** *Mechanika,* no. 4, 99–111, 1956.

Author applies the perturbation method to the problem of stability of a bar with discontinuously variable cross section $J/x = J_s [1 + \beta\phi(x)]$. The discontinous function $\phi(x)$ is approximated by means of a few terms of a trigonometrical series, and three terms of the expansion of the critical force in a power series in β are taken into account. Calculations are carried out in three concrete cases. M. Sokolowski, Poland

2079. Lokshin, Kh. M., On a particular characteristic of the equation of stability of an elastically held beam (in Russian), *Issled. po teorii sooruzheniy* no. 6, 117–122, 1954; Rev. no. 1691, *Ref. Zh. Mekh.* 1956.

The stability of an elastically constrained beam is examined.

Author uses a symbolical method of notation for the equation of stability, incorporating special functions.

The application of the suggested method is illustrated on the example of an angle beam one end of which is constrained, and the other end hinged to a support. A .V. Dyatlov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2080. Jasinski, F., Investigation of rigidity of compressed bars (in Polish), *Arch. Mech. stos.* **8**, 3, 319-390, 1956.

This is a new abbreviated edition of the classical Jasiński discussion published first in Russian and French in 1894, and in Polish in 1895.

The investigation contains among other problems: (1) the explanation of the fact that the integration of the approximate differential equation, constituting a base for the determination of Eulerian critical force for buckling, leads in the limit case to the same result as the integration of the accurate equation; (2) the calculation of a critical force for buckling in four classical cases of clamping the ends and for twelve other cases; (3) an analysis of the influence of eccentric attachment of compressive force and initial curvature of a bar on the strength and the stability of the bar. W. Urbanowski, Poland

2081. Kleeman, P. W., The buckling shear stress of simply supported, infinitely long plates with transverse stiffeners, *Aero. Res. Counc. Lond. Rep. Mem.* 2971, 18 pp., 1956.

The title problem is treated for plates with equally spaced transverse stiffeners. The solution is obtained by means of the Lagrangian multiplier method. The effect of bending and torsional rigidity of the stiffeners upon the buckling shear stress is calculated for the complete range of stiffnesses, for panels with ratios of width to stiffener spacing of 1, 2, and 5. Numerical results are given in tabular and graphical forms. They show the considerable influence of the torsional rigidity of the stiffeners upon the critical stress of the plate.

V. Bogunovic, Yugoslavia

2082. Walczak, W., A case of loss of stability of a rectangular plate loaded with concentrated forces (in Polish), *Zesz. Nauk. PL* **10**, *Mechanika*, no. 4, 89-97, 1956.

A deflected rectangular plate, simply freely supported on all edges and loaded with a concentrated force, acting in the region of the plate along its axis of symmetry, is discussed. A simplified stress distribution in the plate is used assuming that the reaction at its edge has the form of a concentrated force and limiting the region of normal stresses other than zero to a segment connecting the points of action of the forces. The approximate value of critical forces for various plate dimensions and various points of action of the forces is obtained, using the well-known energy method of Timoshenko. M. Sokolowski, Poland

2083. Rockey, K. C., The design of intermediate vertical stiffeners on web plates subjected to shear, *Aero. Quart.* **7**, 4, 275-296, Nov. 1956.

Paper reports on tests to determine critical shear buckling loads of stiffened-web plate girders. The effectiveness of single versus double-sided web stiffeners and variations in their stiffness is investigated. Author proposes a new formula governing the required size of stiffeners to develop the critical shear stress coefficient. The formula results in much larger size stiffeners than are now being used for webs with aspect ratios of 0.4 to 1.4.

I. A. Benjamin, USA

2084. Nash, W. A., Buckling of initially imperfect cylindrical shells subject to torsion, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-36, 6 pp.

Paper deals with an approximate large-deflection theory of cylindrical shells subjected to torsion. Starting with Donnell's equations, author writes an expression for the potential energy of the shell. In terms of arbitrary constants, deflection functions are chosen to approximate buckling configurations for clamped ends and for simply supported ends. Hence, the potential energy of the shell is expressed in terms of arbitrary constants. By the principle of stationary potential energy, these arbitrary constants are determined. Shear-twist diagrams are obtained for various values of an imperfection factor V. Based on experimental observations, an expression for V, in terms of shell parameters and the load, is recommended. As the imperfection factor increases, the minimum load for which a buckled form may exist decreases. However, it is interesting to the reviewer that, for reasonable imperfection factors ($V < 1$), this minimum load is not much less than the minimum load for which a buckled form can exist in the ideal shell ($V = 0$). A. P. Boresi, USA

Joints and Joining Methods

(See also Revs. 2130, 2152, 2287)

2085. Lubkin, J. L., A theory of adhesive scarf joint, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-52, 6 pp.

Calculation of adhesive joint strengths by elastic theory carries uncertainties due to ultimate nonlinear elastic behavior of adhesives. Author considers that in special case of tension-loaded scarf joint between identical adherends it is permissible to apply stress distribution for elastic region to the range beyond the proportional limit. Analysis indicates uniformity of stress distribution to be independent of scarf angle and adhesive thickness when the latter is very small in relation to adherend thicknesses. Assumption is then made that distribution remains uniform beyond proportional limit, which reviewer believes to be reasonable, thus enabling calculation of failure load in terms of a yield criterion. Best criterion is found, by comparison of theoretical with test data of variation of failure load with scarf angle, to be equality of maximum tensile stress in adhesive layer to tensile-failure stress of adhesive. E. C. Williams, England

2086. Misztal, F., Stress distribution in glued single and multi-joints of sheets subjected to shear along the splice line, *Bull. Acad. Polonaise Sci. Cl. IV* **4**, 1, 21-27, 1956.

Author considers various interesting adhesive-joint problems of a type common in aircraft structures. Assume two thin sheets, lap-jointed along a long straight edge with uniform overlap, by means of a thin adhesive layer. Loading is not the previously-treated tensile type but consists of a shear flow, wherein a uniform load per unit length, parallel to the free edges of the adherends, is transmitted from one member to the other. Under suitable simplifying assumptions, including the use of Hooke's law for all members, the problem is rendered one-dimensional, and a solution is obtained for the shear stresses in the adhesive layer. These are largest at one or both of the ends of the joint. Generalizing to include case of three sheets joined by two adhesive layers, author finds largest adhesive stresses still at the free edges, and concludes that the element introducing the greatest shear flow should be placed between the other two. If plates are made thicker, author extends analysis to show that some of his assumptions become inaccurate, but this has negligible effect on the computed adhesive stress distributions. J. L. Lubkin, USA

2087. Roth, H., Calculation of bolted frame corners (in German), *Stahlbau* **25**, 11, 278-281, Nov. 1956.

2088. Winter, G., Light gage steel connections with high-strength, high-torqued bolts, *Publ. int. Assn. Bridge struct. Engng.* **16**, 513-528, 1956.

Structures

(See also Revs. 2042, 2060, 2072, 2077, 2080, 2152, 2157, 2191, 2289, 2310, 2362, 2372)

Book—2089. Leonhardt, F., and Baur, W., Prestressing with concentrated stress members, Berlin, W. Ernst & Sohn, 1956, 88 pp., 98 illus.

This book—an important addition to Leonhardt's book "Spannbeton fuer die Praxis," Berlin, W. Ernst & Sohn, 1955—describes various methods used for the installation of stressing devices which basically consist of jacks inserted between two portions of concrete at each end of the structural member. The following characteristics and advantages of the improved Baur-Leonhardt method are presented: (1) Stress cables of a girder are more concentrated and preferably are installed in a sheet-metal channel. (2) Cables of parallel wires or strands are arranged in several horizontal layers with small spacings allowing proper embedding in injected cement mortar. (3) The stressing cables are arranged in polygonal shape, the straight sections, 6–25 ft long, being interconnected by short channel sections in such a way that no friction can affect the posttensioning. (4) These connections are replaced by curved sections in continuous girders over the supports. (5) If the angle between straight sections is sharper, special sliding sheets are inserted in order to decrease the friction. (6) Anchorage of cables in one or more channels is achieved simultaneously by winding them around reinforced-concrete anchor blocks, and the cables are stressed all at once by hydraulic jacks inserted between these blocks and the girders, thus reducing the number of stressing operations. (7) Such concentration of stressing members with special hydraulic jacks of high tension (300–500 tons) has the advantage that coarse concrete aggregates with high compressive strength and low plastic flow and shrinkage can be used. (8) Large anchor blocks and channel plates transmit the stress forces more uniformly into the girder. (9) Simultaneous stressing of greater cable group makes better control of stress intensity possible.

Details and fabrication of slide channels in steel and in reinforced concrete are thoroughly discussed and illustrated, and various types of anchor blocks and jacking devices described. Special chapters refer to construction operations, especially installation of hydraulic presses, injection of fine cement mortar, measurement of stress intensities, concreting of the girder bodies, etc. Of great interest is the list of selected bridges (108) built on the basis of these principles not only in Germany, but also in the USA, South America, Switzerland, Austria, Norway, in the period 1949–1956.

Credit for these improvements is given also to W. Andrä. References are given to publications by C. Klett, W. Stöhr, H. Gass, U. Giehrach, Ch. Sättele, R. Bauer, R. Hemmleb, G. Steinmann, U. Seetzen, E. Zschierich, E. Scheibe, A. Lämmlein, and M. Ellinger. J. J. Polivka, USA

2090. Herzog, M., Diagrams for the design of reinforced concrete in the elastic region ($n = 10$), *Schweiz. Bauztg.* **75,** 7, p. 93, Feb. 1957.

2091. Schjödt, R., Pressure of concrete on forms and pore-water pressure (in German), *Beton u. Stahlbeton.* **51,** 11, 241-243, Nov. 1956.

This is essentially a repetition and evaluation of formulas and diagrams given in author's earlier paper [AMR **9,** Rev. 733]. Closing example shows great influence of form impermeability on concrete pressure sometimes exceeding permissible strength of form material. W. Mudrak, Austria

2092. Vajda, P., The assembly of prefabricated components made of reinforced concrete for the construction of hangars (in German), *Publ. int. Assn. Bridge struct. Engng.* **16,** 499–512, 1956.

2093. Goretsky, L. I., The calculation of reinforced-concrete coverings (road and runway surfaces) (in Russian), *Trudi Khar'kovsk. avtomov.-dor. in-ta* no. 17, 33–41, 1954; Rev. no. 1727, *Ref. Zh. Mekh.* 1956.

Calculations made for concrete, reinforced-concrete, and ferroconcrete (road) coverings show that greatest economy is attained by a reinforced covering, with a considerably smaller percentage of reinforcement than in ordinary ferroconcrete, compared with straight concrete coverings. A. S. Kozhevnikov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2094. Seddon, A. E., Concrete walls in compression under short-term axial and eccentric loads, *Publ. int. Assn. Bridge struct. Engng.* **16,** 457–468, 1956.

2095. MacIntosh, R. H., Bolton, J. D., and Muir, C. H. D., No-fines concrete as a structural material, *Proc. Instn. civ. Engrs.* **5,** 6, 677–694, Nov. 1956.

No-fines concrete has for a number of reasons developed extensively in recent years as a material for building houses. Expanding production has encouraged research into the characteristics of the material and has led to advances in technique of building with it.

Paper details these characteristics, the most important of which are specific weight, compressive strength, resistance to moisture penetration, and thermal and sound insulation values. The advantages provided by these characteristics, and also the limitations, dictate that economic architectural and structural design must proceed with full recognition of them; the best manner in which to utilize these characteristics is discussed.

Methods of construction adopted in Great Britain have usually involved the use of formwork constructed in very large units and have been accompanied by a high degree of mechanization. Methods of mixing and placing are described, also protection from the weather, and comparison is made with traditional methods of building in respect to economy and speed of construction. The material is especially advantageous where manpower is scarce or expensive.

Where the maximum potentialities of no-fines concrete in compression must be developed, as in tall buildings, careful mix design and control of quality is essential. It has been found that compressive strength bears a clear relation to relative specific weight, that the latter can vary considerably in practice, and that this can cause important variations in the compressive strength of walls. The degree of compaction in these circumstances is an important factor in control, and, if capable of measurement, can be used to interpolate the range of compressive strength obtained in practice. From authors' summary

2096. Goodey, W. J., Matrix analysis of the circular conical fuselage. Parts I, II, III, *Aircr. Engng.* **24,** 335, 2–10, Jan. 1957; **24,** 336, 47–55, Feb. 1957; **24,** 337, 77–88, Mar. 1957.

Paper describes a minimum energy solution which can be applied to fuselages with cut-outs and which include the following effects: shear in skin, normal stress in stringers and longerons, shear and bending in the frames. In this respect, the analysis includes a consideration of the same effects as those considered previously by Cicala [AMR **1,** Rev. 629] and N. Hoff et al [*NACA TNs* 938, 939, 968, 999, 1013, 1014, 1264, 1263, 1436, 1962, 1963]. Simple problems are solved to illustrate the applications of the method. The development is given in a matrix form which, the author states, enables one to program the simpler cases for desk computers and the more complicated cases for electronic digital computers.

The method does not include the effects of bending of the longeron at the cut-out, which a more elaborate theory due to Liner and Jupe (presented and utilized in Bristol Airplane Company reports) indicates may cause critical stress conditions in the longeron and also in the frames and stringers in the neighborhood of the cut-outs. S. F. Borg, USA

2097. Clarkson, J., The design for minimum weight of simply-supported flat grillages to withstand a single concentrated load, *N. E. Cst. Instn. Engrs. Ship. Trans.* **73,** 3, 145–155, Jan. 1957.

Elastic design of flat orthogonal grillages or gratings (for such uses as bridge decks, floors of buildings, ship-bottom structures, etc.) is considered from the viewpoint of minimum weight to withstand concentrated loads. Calculated values of bending moments are provided for a considerable range of "uniform" grillages (equal and evenly spaced beams in each direction). A suggested procedure for design use is illustrated by a numerical example. H. J. Grover, USA

2098. Jensen, E., Nielsen, A. B., and Nielsen, J., Computations of tables for design of collar roof trusses for saddle roofs (in Danish), *Bygnsstat. Medd.* **27,** 4, 265–279, Nov. 1956.

Formulas arrived at are illustrated by diagrams in which the abscissae represent the ratios of width of section of rafter in inches to spacing of rafters in meters, while the ordinates represent the ratios of height of timber section in inches to length of truss in meters. The tables are derived from these diagrams.

The tables may be used for trusses of forms varying to some degree from those assumed in the computations; the pitch of roof should, however, lie between 30° and 50° and the collar beam should be placed within the middle third of the height of truss. From authors' summary

2099. Wakabayashi, M., Experimental studies on composite structures (in Japanese), *Rep. Inst. Indust. Sci. Tokyo Univ.* **6,** 2, 63 pp., Dec. 1956.

The composite structure tested in the present investigation is a monolithic solid structure of concrete having steel bars placed around a fabricated steel core-section. In Japan, composite structures of this kind are usually applied to the construction of buildings with more than six stories.

The tests include: (1) Beams subject to bending; (2) columns subject to combined bending and axial forces; (3) beams subject to shear; (4) columns subject to axial and shearing forces; (5) connections subject to bending; and (6) bond strength between steel and concrete.

In the tests on beams subject to bending, the cooperating action of reinforcing bars with the steel section was investigated, and the coincidence of the ultimate strength of the test beam with a calculated value was observed. From the tests on columns subject to combined bending and axial force, the validity of the ultimate strength formula was confirmed and the parameters which express the shape of the stress block in concrete were determined. In the tests on beams subject to shear, many beams of ordinary reinforced-concrete sections and of composite sections of the same size were tested, and the effect of tie and lattice plates was compared with that of stirrups. In the tests on columns subject to axial and shearing forces, the ultimate strength of composite sections was compared with that of reinforced-concrete sections of the same size. In the tests on connections of beams and columns subject to bending, the coincidence of theoretical values with the ultimate strength of the test pieces within small errors on the conservative side was observed. In the tests on bond strength between steel and concrete, besides the ordinary pull and push-out tests of flat bars, unique pull-out tests were made in which the concrete on the sides of the plates comes to be subjected to shearing when the sliding of the plate occurs. S. Okamoto, Japan

2100. Jaeger, T., Research and methods of limit analysis of framed structures of mild steel. Part I (in German), *Bauplanung Bautech.* **10,** 7, 266–279, July 1956.

Since G. Kazinczy in the *Hungarian Concrete Review* [*Beton Szemle* **2,** 4–6, 1914] first treated the problem of limiting load of rolled steel girders, and introduced the concept of yield hinges, quite a new branch of science has developed from his suggestions. Autho. gives in this article, as well as in an earlier paper of similar subject matter, [*Bauingenieur* **31,** 8, 273–291, Aug. 1956], a lucid review of this novel branch of science, intensively expounding the present state of theoretical and experimental research in that line. A very comprehensive review, principally of the British and American literature, completes the paper.

The first part of the paper deals with basic principles of limit analysis. The case of simple proportional loading is first treated with detailed enumeration of assumptions and theorems that form the basis of analysis and of design. Theorems relative to the statically and dynamically permissible multipliers are discussed in detail here. Next, the case of alternating loading is treated, with sharp distinction between the cases of alternating plasticity, increasing plasticity, and shake-down. There follows a synopsis of theoretical and experimental investigations on the calculation of the carrying capacity of steel structures.

Finally, possibilities of application of the method of design based on limit analyses and the degree of economy thereby attainable are discussed. P. Csonka, Hungary

2101. Jaeger, T., Research and methods of limit analysis of framed structures of mild steel. Part II (in German), *Bauplanung Bautech.* **10,** 8, 315–324, Aug. 1956.

The second part of the paper [see preceding review] is an excellent review of the different methods of analysis and design of plane bent structures in the plastic range. Among others, the so-called closing-line method is presented, which is especially expedient in application to statically not-too-indeterminate structures. Methods are recapitulated which attain their objectives by a system of linear inequalities. The methods of Neal and of Symonds are described in detail, and, in connection with a numerical example, the determination of the collapse or shake-down loads for a framed structure is presented. Afterwards, the Heyman-Nachbar method is discussed in detail, which makes possible the closure of the critical load factor between convergent limits. The application of this method is shown in a practical example. The method of the combination of simple kinematic chains is presented and explained on a numerical example. Finally, the relaxation of yield hinges is treated. P. Csonka, Hungary

2102. Jaeger, T., Research and methods of limit analysis of framed structures of mild steel. Part III (in German), *Bauplanung Bautech.* **10,** 9, 361–371, Sept. 1956.

The third part of the paper explains Horne's moment-distribution method for the analysis and design of structures by plastic theory. As an example of application of this method the analysis and design of a three-legged single-story framework is presented. The principles are expounded by which the design of a framework in bending with minimum weight becomes possible.

Author discusses how, in the application of limit analysis, the effect of bending moments and of axial forces on plane framed structures can be simultaneously taken account of. In the treatment of such problems it is expedient to introduce the concept of the eccentrically located plastic hinge. The possibility of observing combined bending and torsion is shown in detail. In connection with this, the design in the plastic range of grid-works loaded by forces normal to their planes is dealt with separately.

Finally, the limit analysis of the statically indeterminate truss is treated. Author establishes under what conditions it is permissible to apply the methods of determination of the limiting load of statically indeterminate structures in bending to the calculation of limiting load of these structures.

P. Csonka, Hungary

2103. Ter-Israelyan, V. A., Calculation of a low pyramidal envelope of square plan (in Russian), *Sb. nauch. trudi Erevansk. politekhn. in-ta* no. 9, 21–33, 1955; Rev. no. 1617, *Ref. Zh. Mekh.* 1956.

The calculation is performed on the basis of the engineering theory of elastic flat envelopes, by means of linearly distributed impulse (momentum) functions. The surface of a pyramidal envelope is substituted by a smooth auxiliary surface. The equations are solved by Bubnov's method. The deflection and stress functions are stated in the form of double trigonometric series (expanded sinusoidally). A numerical example is given, from which the author concludes the economy of roof coverings of such type.

Courtesy of Referativnyi Zhurnal P. A. Lukash, USSR
Translation, courtesy Ministry of Supply, England

2104. Yershov, N. F., On the calculation of the stiffeners of a ship's skin plating (in Russian), *Nauch. trudi Odessk. in-ta inzh. mor. flota, Jubilee number,* Moscow, 286–298, 1955; Rev. no. 1708, *Ref. Zh. Mekh.* 1956.

The problem is examined of calculating the strength of intermediate frame stiffeners, as fitted in vessels for navigating in ice, and the influence of such frames on the strength of the skin plating.

The skin plating is regarded as formed of flanged strakes, and the problem reduced to the bending of a lap with a single transverse joint. The boundary conditions for the plates and stiffeners are very approximately stated. A. A. Kurdyumov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2105. Mazilu, K., The three-dimensional calculation of frameworks with principal longitudinal and secondary transverse beam members (in Russian), *Nauka v Rum. Nar. Resp.* no. 2, 173–198, 1953; Rev. no. 1679, *Ref. Zh. Mekh.* 1956.

The static calculation is described of a system consisting of a series of reinforced-concrete spans supported on columns. The method of angular deformations is applied. The calculation includes the cases of immovable and movable joints. Allowance is made for the work of torsion in the corresponding members. Numerical examples are given.

Courtesy of Referativnyi Zhurnal A. A. Shcheglov, USSR
Translation, courtesy Ministry of Supply, England

2106. Kravtsov, A. A., Application of the equalizing method in the calculation of statically indeterminate, triply supported, symmetrically loaded beams and frameworks (in Russian), *Izv. Akad. Nauk SSSR* no. 2, 143–155, 1954; Rev. no. 1683, *Ref. Zh. Mekh.* 1956.

The method described was suggested by N. M. Bernadsky [*Trudi Sredneaz. opyt. n.-i. in-ta vodn. kh-va,* no. 3/13, 1929] and in 1930 by Cross. In the particular case examined, author applies the method in such form that no stepwise approximation is necessary, and the result can be written directly.

Courtesy of Referativnyi Zhurnal I. M. Rabinovich, USSR
Translation, courtesy Ministry of Supply, England

2107. Rasmussen, B. H., Incremental collapse of statically indeterminate structures (in Danish), *Bygnsstat. Medd.* **27**, 4, 239–264, Nov. 1956.

After a brief review of the theory and the existing test reports, a series of tests on reinforced-concrete beams recently undertaken at the Research Laboratory of Building Technique of the Technical University of Denmark is discussed.

It is shown that the modified limit design approved by the Danish standard specifications for reinforced-concrete structures or steel structures generally provides an appropriate factor of safety against incremental collapse.

Finally, a statistical approach to the problem is mentioned.

From author's summary

2108. Charlton, T. M., Statically indeterminate frames; the two basic approaches to analysis, *Engineering* **182,** 4738, 822–823, Dec. 1956.

2109. Popov, A. A., The graphical calculation of continuous beams and frameworks by the method of focal points (in Russian), *Issled. po teorii sooruzheniy* no. 6, 197–219, 1954; Rev. no. 1685, *Ref. Zh. Mekh.* 1956.

A method is described for plotting the diagrams of bending moments for continuous beams with immovable and movable joints, based on application of the method of focal points [A. A. Popov, "Novy metod integrirovaniya pri pomoshchi ortogonal'nykh fokusov," Gostekhizdat, 1947; "metod ortogonal'nykh fokusov v stroitel'noy mekhanike," Gosstroiizdat, 1953].

Courtesy of Referativnyi Zhurnal G. S. Glushkov, USSR
Translation, courtesy Ministry of Supply, England

2110. Geniev, G. A., A stability analysis of flat elastically supported hinge chains (in Russian), *V. sb. Issledovaniya po stroitel'noy mekhanike,* Moscow, Gos. izd-vo lit. po str-bu i arkhtekture 79–89, 1954; Rev. no. 1692, *Ref. Zh. Mekh.* 1956.

An analysis is given of the stability of flat, vertical walls, loaded by their own weight, consisting of rigid, rectangular elements interconnected by cylindrical hinges and constrained by elastically yielding supports in the plane of each hinge.

The condition of stability is obtained by equating to zero the determinant of the system of homogeneous equilibrium equations set up for the hinges of the system. An evaluation is thus obtained of the number of rows (tiers) at which the system still remains stable. A. I. Vinogradov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2111. Mierzejewski, J., Computation of special crane trusses (in Polish), *Zesz. Nauk P. Gd.* **4,** *Mechanika* 1, 3–78, 1956.

Paper concerns a computation method for articulated space trusses, supported in a statically determinate manner and asymmetrically loaded. This results in the truss being subjected to torsion.

The method is accurate in the case of statically determinate trusses and gives a sufficient approximation in the case of internally statically indeterminate trusses. Its application does not involve any serious arithmetical difficulty.

The method is illustrated by numerical examples and the differences between the accurate and the approximate method in which bars are computed as for plane trusses are explained. These differences are important and should not be neglected in computations of truss crane structures.

J. Naleszkiewicz, Poland

2112. Rutecki, J., The torsion of a thin-walled rectangular tube beyond the elastic limit (in Polish), *Arch. Mech. stos.* **8,** 1, 29–40, 1956.

Normal stresses along the edges when full plasticity of the cross section is just reached are assumed to be of constant absolute value and to change sign at the middle point of the edge. The tangential stress is assumed to be constant along the short edge and to have its absolute value constant along the long

edge, the sign changing at two symmetrically placed points.

These assumptions and equilibrium conditions permit deriving relations between the values of the twisting moments M_s, the bimoment B, and the bending-twisting moment $M_w = dB/dz$ in the state of stress corresponding to the full plasticity of the cross section.

Error due to the assumption of fully plasticized cross section is analyzed. This error does not exceed 3.8%.

W. Urbanowski, Poland

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2023, 2043, 2050, 2066, 2112, 2126, 2138, 2170)

2113. Green, A. E., Hypo-elasticity and plasticity. II, *J. rational Mech. Analysis* **5,** 5, 725–734, Sept. 1956.

The discussion of a preceding paper [AMR **9,** Rev. 1807] is extended to compressible work-hardening solids. The transition to zero work-hardening is discussed; in particular it is shown that, under the assumptions introduced in the first part of the paper, the yield condition of the resulting perfectly plastic solid must be of the Mises type.

W. Prager, USA

2114. Naghdi, P. M. Stresses and displacements in an elastic-plastic wedge, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-20, 7 pp.

Authors consider a wedge with an included angle β of elastic, perfectly plastic incompressible isotropic material in the state of plane strain. First, the fully elastic solution in terms of polar coordinates of the wedge subjected to a uniform normal pressure on one boundary is discussed, with curves for stresses plotted. Next, the complete elastic-plastic solution is discussed. It is shown that plastic regions are independent of r, and depend only upon the central angle $\theta(\theta < \beta)$. Yield condition is that of Mises, while for the stress-strain relation in the elastic-plastic range Prandtl-Reuss law is used. A numerical example for $\beta = \pi/4$ is given in detail, and corresponding curves for stresses and displacements are plotted.

Z. Karni, Israel

2115. Thomsen, E. G., A new method for the construction of Hencky-Prandtl nets, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-14, 4 pp.

Method is relevant to construction of slip-line nets in problems of plane plastic strain. It involves use of cardboard wedge whose angle is equal to angular spacing between adjacent slip lines. Author proves theorem governing manner in which wedge must be moved to generate a new slip-line from a known one. Presentation is solely in relation to special equiangular net defined by equal centered fans (for which accuracy is good), and it is not made clear how far this is a necessary restriction. It seems unlikely that method would be practicable when slip-line families are neither centered nor equiangular, as happens, for example, when there is a Coulomb-friction type of boundary condition.

Reviewer is entirely satisfied with existing graphical and computational methods, which are easy for engineers to master and are flexible and not subject to restrictions.

R. Hill, England

2116. Truszkowski, W., Stress-strain relationship for tensile-tested metals, *Arch. Mech. stos.* **8,** 4, 581–595, 1956.

This paper sums up the results of the investigations by A. Krupkowski and W. Truszkowski concerning the establishment of an analytical relation between the stress and the cold work in the first period of plastic deformation.

Author distinguishes three ranges of deformation of plastic metals: the first, from the elastic limit to the limit of uniform elongation; the second, corresponding to the formation of the neck up to the ultimate strength; the third range being the final range.

For the first range, the following semi-empirical equation is proposed: $\sigma = K z_i^m$ (σ is the real stress, z_i the theoretical cold work, and k and m constants for given material).

Numerous investigations of metals and alloys have shown good agreement between this equation and experiment in the first range of deformation.

A method for determining the constants and their physical meaning is discussed. The values of these constants and associated constants for fifteen metals and alloys are shown in a table.

W. Urbanowski, Poland

2117. Forkert, L., On nonlinear deformations (in German), *Öst. Bauzeitschr.* **11,** 10, 235–238, Oct. 1956.

Analysis of bending of beams is developed using result $dW = Mdk$, where W is energy of unit length of beam, M is bending moment and k is curvature. The case $k = \kappa \sinh \lambda M$ is treated in detail. Three special cases are treated fully: (a) uniform beam hinged at ends and loaded at a single point, (b) uniformly loaded cantilever, (c) the statically indeterminate case of a beam clamped rigidly at both ends and loaded symmetrically at two points.

F. R. N. Nabarro, South Africa

2118. Olszak, W., and Urbanowski, W., The plastic potential and the generalized distortion energy in the theory of nonhomogeneous anisotropic elastic-plastic bodies, *Arch. Mech. stos.* **8,** 4, 671–694, 1956.

The so-called quadratic yield condition is established and discussed for nonhomogeneous bodies of the most general type of anisotropy. The results are presented in two alternatives. In the first, authors base their consideration upon von Mises' hypothesis concerning the plasticity potential of anisotropic bodies. It is shown that the von Mises definition of the plasticity potential assumes that the body is incompressible, and its potential is expressed by a quadratic form.

In the second alternative the yield condition assumed presents a generalization of the energy hypothesis of M.T.Huber. As the elastic energy of distorsion is not unequivocally defined for bodies of the most general type of anisotropy, authors introduce the idea of two kinds of generalized distorsion. The value of the energy of the first kind does not vary with the bulk deformation; the value of the generalized energy of the second kind does not vary with the hydrostatic stress.

The paper throws a new light upon the ideas of the plasticity potential and the distorsion energy.

J. Murzewski, Poland

2119. Hodge, P. G., Jr., The theory of piecewise linear isotropic plasticity, Deformation and flow of solids, Colloquim Madrid, Sept. 26–30, 1955, 147–170; Berline, Springer Verlag, 1956.

Author reviews some of the theories of plasticity from the point of view of usefulness to engineers and has set up criteria whereby he has drawn conclusions relative to distribution of forces throughout the walls of cylindrical members subjected to internal pressures which cause plastic yielding at the inside of the vessel wall. He also shows a comparison between what he calls actual displacement as compared with the displacement calculated from the potential energy theory and from the complementary energy theory. He concludes, however, that experiments designed to check the validity of his conclusions would be very good if they could decide the truth or falsity of the various theories he has proposed. He does not conclude, however, that such tests would be good to determine general characteristics of his so-called actual curves.

R. G. Sturm, USA

2120. Hasselgruber, H., On the evaluation of stresses occurring due to tightening of screws on an inclined base (in German), *Forsch. Geb. Ing.-Wes.* **22,** 3, 95–101, 1956.

When tightening screw joints on an inclined base, the stress distribution in the cross section of the screw is striving for a steady final state under the condition that the assumption is justified of the screw material not being strain hardening. In this case the march of stress and the transmitted total tension load can be calculated. This problem dealt with represents an example of application to the theory of the ideally plastic bodies when submitted to a permanent alternation of loading and unloading.

From author's summary

2121. Feltham, P., On the mechanism of high-temperature creep in metals with special reference to polycrystalline lead, *Proc. phys. Soc. Lond.* (*B*) **69,** 444, 1173–1188, Dec. 1956.

An investigation of the high-temperature transient and equilibrium creep rates is reported upon. The defining expression is obtained in terms of the applied stress, the temperature, the grain size, and the characteristics of the intergranular structure. The equation is checked and found to agree reasonably with the published creep behaviors of several metals. Parameters A and q are investigated in considerable detail, using lead. These data are utilized in a better theoretical interpretation of the mechanism of creep. The parameter q is found to be very nearly independent of stress but quite dependent upon temperature and of greater significance than A. The experimental equipment and results are presented and the creep mechanism discussed.

J. P. Vidosic, USA

2122. Laks, H., Wiseman, C. D., Sherby, O. D., and Dorn, J. E., Effect of stress on creep at high temperatures, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-55, 7 pp.

Experimental investigations on pure aluminum and its dilute solid-solution alloys revealed that the high-temperature creep rate $\dot{\epsilon}$ is related to the stress σ by $\dot{\epsilon} \sim \sigma^n$ for low stresses and $\dot{\epsilon} \sim e^{B\sigma}$ for high stresses where **n** and **B** are constants independent of the creep strain and temperature. According to a preliminary dislocation-climb model for high-temperature creep, the activation energy for creep is that for self-diffusion and the effect of stress on the creep rate depends on the number of active Frank-Read sources, and the rate of climb depends on the structure as determined by the pattern of climbing dislocations. Many of the experimental observations on high-temperature creep can be accounted for by this model. From authors' summary

2123. Vidal, G., Periodic creep of heat-resistant alloys (in French), *Rev. Metall.* **53,** 7, 485–496, July 1956.

Predictions regarding the creep behavior of high temperature alloys of the Nimonic (Ni-Cr-Co) type under the combined effect of mean and alternating stresses have been attempted using simplifying assumptions as follows: (a) the recovery is neglected; (b) the creep rate is time independent; (c) a power function relation exists between the creep rate and applied stress; (d) the elongation at fracture is independent of time and mode of load application. The prediction is limited to cases for which the lower range of the stress is not a compression. Under these assumptions it is possible to define an effective stress such that it will produce rupture after a given length of time regardless of any other factor involved.

Tests performed at 800 C under low (1.4×10^{-4} Hertz) and medium (33 Hertz) frequencies showed that the times of rupture (of the order of 50 hrs in one case and 200 hrs in the other) were indeed of the same order of magnitude at each frequency for various ranges of stress. Yet at medium frequency, the rupture under high alternating range exhibited the characteristic feature of fatigue. The difference in time between the two sets of data was ascribed to the chemical composition and type of specimen rather than change of frequency. The elongation at fracture was not reported. D. Rosenthal, USA

2124. Oldroyd, J. G., The effect of small viscous inclusions on the mechanical properties of an elastic solid, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 304–313; Berlin, Springer Verlag, 1956.

Generalized material constants forming operators are introduced in strain-stress relations and determined for tension and shear by considering the equation of motion and the equality of stresses and displacements of both materials at the surface. The properties of deformation of any uniform viscoelastic solid with small inclusions of another material are deducible. Coincidence with known special cases is stated.

F. Schultz-Grunow, Germany

2125. Mason, W. P., Dislocation relaxations in metals and single crystal quartz, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 314–322; Berlin, Springer Verlag, 1956.

Ultrasonic attenuation measurements on face-centered metals in the range of small tensions and low temperatures are investigated theoretically on basis of dislocation model for relaxation effect. The high resonance frequency of model shows the frequency independence of friction. The number of dislocations, the average form of model loops, the ratio of Peierls stress to shear modulus are calculated, as well as the internal friction dependent on temperature. Influence of impurities is considered.

F. Schultz-Grunow, Germany

Failure, Mechanics of Solid State

(See also Revs. 2050, 2107, 2143, 2147, 2148, 2149, 2234)

Book—2126. Jaeger, J. C., Elasticity, fracture and flow with engineering and geological applications, London, Methuen & Co., Ltd.; New York, John Wiley & Sons, Inc., 1956, viii + 152.

Chapter 1 gives a detailed and very clear analysis of stress and strain without attempting to relate the two quantities. Among the topics discussed are Mohr's representation of stress in three dimensions and finite homogeneous strain in three dimensions.

In chap. 2 the stress-strain relations are developed for elasticity, plasticity, viscosity, certain rheological models, and anisotropic elasticity. Yield and fracture criteria are discussed. In addition to covering the field which is, or should be, covered by mechanical engineering graduate courses, Professor Jaeger gives an interesting discussion of geological failure theories. At all times the assumptions are clearly stated, and the development is logical and easy to follow.

The third and final chapter introduces the equations of motion and equilibrium to solve a number of special problems. Elastic wave propagation, the flow of a viscous fluid, and two-dimensional plasticity are used to show the different behavior of three types of materials.

Reviewer heartily recommends this surprisingly small and inexpensive book. It will be valuable as a general reference work in addition to its value as a textbook at a graduate level. A number of well-chosen literature references are given throughout the book.

I. Finnie, USA

2127. Crum, R. G., and D'Appolonia, E., Fatigue damage measured by deflections of rotating beam specimens, *Proc. Soc. exp. Stress Anal.* **14,** 1, 71–82, 1956.

Apparatus described records continuously, during rotating beam fatigue test, the deflection of and torque supplied to specimen. Results (not given in detail) suggest that specimen initially behaves elastically above the elastic limit and that expected static plastic deflection is only reached after a number of cycles. It is postulated (and apparently confirmed) that damage from cyclic loading starts only when deflection reaches the latter value.

R. N. Arnold, Scotland

2128. Holt, M., and Matthiesen, R. B., Fatigue tests of riveted or bolted aluminum alloy joints, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 1 (*J. Struct. Div.*), Pap. no. 1148, 28 pp., Jan. 1957

Fatigue test results for aluminum-alloy monobloc specimens, butt joints, and lap joint indicate that specimens with idle rivets have higher fatigue strengths than specimens with open holes; that symmetrical joints have higher fatigue strengths than unsymmetrical joints; and that joints with tightly drawn bolts or flush-head rivets have higher fatigue strengths than joints with protruding-head rivets. The data presented suggest a manner in which current design specifications can be improved. From authors' summary

2129. Choudhary, J. P., Problems of service failure due to fatigue, *J. Inst. Engrs., (India)* **37,** 4 (part 2), 359–371, Dec. 1956.

2130. Stallmeyer, J. E., Munse, W. H., and Goodal, B. J., Behavior of welded built-up beams under repeated loads, *Welding J.* **36,** 1, 27s–36s, Jan. 1957.

Flexural fatigue tests have been conducted on small all-welded beams fabricated from A373 steel. All beams were fabricated by manual arc-welding, using E7016 electrodes and a back-stepping welding procedure. Several field splice configurations were used in the investigation, and studies were made of the difference in their modes of failure as well as the difference in their fatigue strenghts. In addition, the program included fatigue tests on control specimens to determine the fatigue strength of the A373 steel as received from the mill and also with butt-welded joints, either parallel or perpendicular to the direction of stress.

The fatigue tests on the beams indicate that the presence of a splice materially reduces the fatigue strength of a welded beam. A difference in fatigue strength is also revealed for the different splice configurations. From authors' summary

2131. Berry, W. R., The use of shot peening to reduce weight, Instn. mech. Engrs., Preprint, 11 pp., 1956.

The object of this investigation was to explore the possibilities of utilizing the shot-peening process on laminated spring leaves from silico-manganese spring steel as a means of increasing the working stresses, and thus reducing weight without loss in fatigue life.

The first part of the investigation showed that, so far as fatigue tests alone were concerned, it should be possible to increase the working stresses and thus save weight. To do this, however, would involve the bump stress exceeding the primitive elastic limit of the material.

Investigation of the effect of scragging (prestressing) to the British Standards Test Deflexion of $L^2/900t$ as at present adopted in manufacture showed that such scragging had practically no effect on the elastic limit, but that if the scrag deflection was increased to approximately $L^2/400t$, an increase in the apparent elastic limit of the order of 40% of the primitive elastic limit could be obtained, and that such scragging also improved the fatigue life in both the plain and shot-peened conditions.

It is considered that, with effective scragging and shot peening, it is probable that very considerable savings in weight, of the order of at least 20–25%, and under certain conditions even more may be obtainable, provided trouble does not arise due to superimposed stresses of starting and braking torques, and possible embrittlement due to effective scragging. This does not seem to the author to be particularly likely at a weight saving of 20–25%, but can be settled only by service trials which he feels should now be undertaken. From author's summary

2132. Sniderman, A., The concept of strength from Goodman diagrams, *Proc. Soc. exp. Stress Anal.* **14,** 1, 145–154, 1956.

Modified Goodman diagrams are applied to determine the magnitudes of "safety factor" for materials subjected to combined steady and fluctuating stresses. Various relationships between mean stress and maximum, or fluctuating, stress are considered. For each particular relationship a stress line can be plotted on the modified Goodman diagram. The intersection of this stress line with the allowable stress line of the diagram defines the strength of the part for the type of loading considered. Safety factors can then be calculated for corresponding loading types.

I. Vigness, USA

2133. Brice, L. P., General relation between limiting strains of elastic bodies under the influence of arbitrary loads. Theory of the critical volume dilatation. Determination of the direction of slipping (in French), *Ann. Inst. tech. Bât. Trav. publics* **9,** 106, 877–897, Oct. 1956.

A theory of failure is presented according to which the material fails when the volume dilatation reaches a certain critical, constant value. Under the action of arbitrary loads the sphere deforms into an ellipsoid. Making the assumption that only elongations are responsible for the failure, the volume of that part of the ellipsoid which protrudes outside of the sphere must be calculated. In general case the determination of this volume leads to an elliptical inetgral which cannot be calculated algebraically. Several diagrams representing the strain surface at various conditions as well as the slip angle illustrate the exposition.

Experiments with sand, plastic clay, cast iron, and steel are described and analyzed.

A discussion follows in which valid criticism of the proposed theory and praise for the commendable work are expressed.

W. Ornstein, USA

2134. Tarasenko, I. I., On the physical foundations of the deformation and breakdown of metals (in Russian), *Zap. Leningr.-gorn. in-ta* **29,** 3, 67–80, 1954; Rev. no. 1770, *Ref. Zh. Mekh.* 1956.

The available data on the physical foundations of plastic deformation are surveyed in relation to the hypotheses of mechanical strength in transition from one to another stress condition. The work contains no original, experimental data.

Courtesy of Referativnyi Zhurnal P. O. Pashkov, USSR
Translation, courtesy Ministry of Supply, England

2135. David, H. G., The failure of thick-walled cylinders under internal pressure, *Austral. J. appl. Sci.* **7,** 4, 327–335, Dec. 1956.

A number of thick-walled hollow cylinders of nickel-chrome-molybdenum steel have been subjected to internal pressures up to 12,000 atm at room temperature and their yield points determined. The results conform to the Leinss (1955) empirical relation between yield pressure and tensile yield stress.

From author's summary

2136. Oppitz, A., Crank shaft failures—causes and consequences (in German), *Jahrbuch Schiffbautech. Gesellsch.* **49,** 353–388, 1955.

2137. Hundy, B. B., and Boxall, T. D., The repeated strain ageing of mild steel, *Metallurgia, Manchr.* **55,** 327, 27–30, Jan. 1957.

Strain aging of steel takes place after each individual cold-working operation to which it is subjected, and authors' results show that the effects of all aging and cold-working operations on the mechanical properties are additive. If only the last of several cold-working operations is followed by aging, the effect is less than if the steel is aged after each pass. An explanation is offered, based on the dislocation theory of strain-aging.

From authors' summary

2138. Klain, P., Stress-relaxation and stress-relief of some magnesium alloys, *Welding J.* **34,** 9, 415s–423s, Sept. 1955.

The stress-relaxation conditions for several commercial magnesium alloys by the use of the simple beam and cantilever beam methods are presented. Stress-relaxation curves for AZ31A sheet, M1A sheet, ZK60A extrusion and AZ63A, AZ92A and ZK51A castings at several different temperatures and initial stress levels are included and the significant trends discussed. The requirements for stress relief of welded and of machined parts are pointed out. From author's summary

2139. Belyayev, V. I., and Lebedev, T. A., On the development of strain-hardening and relaxation of metal in cyclic tests on samples (in Russian), *Trudi Leningr. politekh. in-ta* no. 4, 123–137, 1953; Rev. no. 1853, *Ref. Zh. Mekh.* 1956.

An investigation of fatigue failure. The test material was an engineering steel with 0.17% carbon. The samples were tested in bending. They were of rectangular form; their surfaces were polished. The microhardness of the surface layers was measured.

It was found that, if the cyclic stresses slightly exceed the fatigue limit of the metal, the microhardness increases during progress of the test in the neighborhood of the points most highly stressed in bending. With increasing number of cycles, the hardness begins to decrease. In other places at the same time, the hardness increases. The increase in hardness is considered by the authors to be related to strain-hardening of the material. The consequent decrease in hardness is explained by relaxation. The investigation has disclosed a "first node" of the test, in which, at a particular number of cycles, a qualitative change takes place in the crystal lattice, its "non-elastic distortion," which is the cause of the appearance of slip lines on the polished surface of the metal samples. I. V. Podzolov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2140. Cahn, J. W., Transformation kinetics during continuous cooling, *Acta Metall.* **4,** 6, 572–574, Nov. 1956.

It is shown that transformations which nucleate heterogeneously will quite often obey a rule of additivity and transform nonisothermally according to simple rate laws which can be calculated from isothermal transformation data. From author's summary

Material Test Techniques

(See also Revs. 2154, 2165)

2141. Rocha, H. A. F., A new nondestructive test tool: the ultrasonic micrometer, *Nondestructive Testing* **14,** 6, 32–34, Nov.–Dec. 1956.

The principle of operation of a pulsed ultrasonic distance meter is presented. Applications are shown to measure thickness by direct contact, and gap dimensions by both contact and noncontact methods. Advantages and limitations are discussed. Future applications are mentioned. From author's summary

2142. Niculescu, D. D., Use of isotopes in testing materials (in Rumanian), *Indust. constr. Mater. constr.* **7,** 3, 169–175, Mar. 1956.

Referring to reports of Russian Concrete Institute and Academy of Sciences, methods are described for testing materials without destruction of samples, e.g., for determining density and moisture of concrete, volume (elevation) of various materials in enclosed containers, such as cement in silos, fluids under pressure, etc. Works by N. Nesmeianov, C. B. Zabarenko, V. A. Leskoviev, Z. Z. Piroinicov are mentioned. J. J. Polivka, USA

2143. Kennedy, A. J., and Slade, R. F., An automatic electromechanical stressing unit for creep and fatigue testing, *J. sci. Instrum.* **33,** 11, 409–410, Nov. 1956.

The apparatus is designed to apply a complex creep and fatigue stressing program to a metal test-piece. A new electrical system has been developed which controls the extension of a mechanical spring in such a way that the test proceeds automatically under either constant stress or constant load, as required. The creep strain and the stress error are recorded during the test. The same system may be used to conduct creep recovery or stress relaxation tests. From authors' summary

2144. Molaroni, A., Microhardness tests and validity of Meyer's law (in Italian), *Metallurgia ital.* **48,** 10, 443–446, Oct. 1956.

With the aim of verifying validity of Meyer's law $P = Kd^n$ in the field of microhardness measurements with loads smaller than 300 gr, some series of prints have been carried out with the Leitz microdurometer on materials with very variable hardness (80 to 800 vickers) and featuring a uniform structure.

For each material investigated, namely four differently heat-treated steels, a stainless steel, a mild steel, and an alpha-brass, the print series have been carried out with loads of 15, 25, 50, 100, 200, 300 gr, in zones far apart from grain boundaries.

The results have been treated with statistical correlation methods, which allowed the exponent n of Meyer's formula and the approximation of data to this formula to be detected.

It has been ascertained that data obtained with different materials verify the said formula with an approximation corresponding to a total experimental error smaller than 1%. The value of n varies within 1.93 and 1.98 according to the material, exception being made for an alpha-brass and an alloy steel, which showed values of 1.90 and 2.07, respectively.

From author's summary

2145. György, K., The penetration hardness of glass surfaces (in Hungarian), *Mérès és Automatika* **4,** 9, 258–263, Sept. 1956.

A diamond cone of the Rockwell-type, in an appropriate scheme, seems to be suitable for testing the microhardness of glass surfaces. When using this method the surface-hardness conditions of the several glass sorts are characterized by the geometric data of the penetration traces originated by charges of 8–800 gr.

The investigation showed additionally that, when a spherical surface penetrates the glass surface, plastic flow ensues at a pressure of 2000 kg/cm². Finally, the tests furnish data on the hardness conditions of the glass surface layers between 0.1 and 2.2 microns. From author's summary

2146. Vitman, F. F., Zlatin, N. A., Ioffe, B. S., and Shestopalov, L. M., Determination of the mechanical properties of metals from a small, conical indentation and a shallow scratch, at high temperatures (in Russian,) *Zh. tekh. fiz.* **24,** 3, 549–559, 1954; Rev. no. 1200, *Ref. Zh. Mekh.* 1956.

An apparatus is described for performing tests on the non-sampling determination of the mechanical properties of metals at high temperatures in a vacuum. The possibility is shown of extending the method of determining the yield point and elastic limit by means of a small, conical indentation, to the high-temperature range. It is found that, for high temperatures, the method of determining the true, ultimate rupture strength from a shallow scratch or notch has not proved satisfactory.

Courtesy of Referativnyi Zhurnal From authors' summary
Translation, courtesy Ministry of Supply, England

2147. Mabie, H. H., and Gjesdahl, M. S., A fatigue testing machine for reversed bending and steady torque, *Proc. Soc. exp. Stress Anal.* **14,** 1, 83–88, 1956.

Fatigue machine described is capable of testing 1-in. diam specimens in reversed bending or with steady torque and reversed bending combined. Test results are given for triangular, square, and keywayed round sections. R. N. Arnold, Scotland

2148. **Temes, C. L., Automatic frequency-control system for a high-frequency resonant-type fatigue testing machine,** *Proc. Soc. exp. Stress Anal.* **14,** 1, 89–98, 1956.

Automatic frequency- and amplitude-control system is described for fatigue machine used to test cantilevers at their resonant frequencies; controller enables testing over frequency range 500 to 2000 cps and maintains constant stress amplitude during the decrease in resonant frequency with fatigue.

R. N. Arnold, Scotland

2149. **Hijab, W. A., A statistical appraisal of the Prot method for determination of fatigue endurance limit,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-50, 5 pp.

Author evaluates Prot method by studying variance of ordinates of regression line representing fatigue life versus square root of rate of increase of stress. Results show Prot method cannot exceed, and in most cases is much less than, the efficiency of either staircase or probit methods. Analysis shows optimum efficiency of Prot method is achieved when only two rates of increase of stress, as widely separated as possible, are used.

Reviewer believes this to be an honest appraisal of Prot method.

D. E. Hardenbergh, USA

Mechanical Properties of Specific Materials

(See also Revs. 2047, 2058, 2095, 2116, 2131, 2137, 2138, 2145, 2146, 2165, 2167, 2288, 2292, 2303)

Book—2150. **Newell, W. C., The casting of steel,** New York, Pergamon Press, 1955, viii + 599 pp. £5 5s.

Book is a cooperative effort of 16 experts and provides steel foundry men and engineers with a reliable and up-to-date guide on the principal technical aspects of steel casting, covering the properties of liquid steels, the mechanism of solidification, the melting process including the use of refractories, pattern making, mould preparation and coremaking, casting into sand moulds, centrifugal casting, investment casting, heat treatment and properties of steel castings, and all aspects of physical testing including radiography. Each chapter is practically self-contained (with its own bibliography).

Due to the large number and variety of contributors both the theoretical and the purely practical information are very sound and based on first-hand knowledge. The book is extremely well documented (about 500 illustrations, over 200 references).

H. R. Fehling, England

2151. **Polakowski, N. H., Observations on the mechanical behaviour of heat-treated steel at high hardness levels,** *J. Iron Steel Inst. Lond.* **185,** 1, 67–74, Jan. 1957.

Untempered martensite behaves in many respects like an annealed metal. It has a low elastic limit which can be raised by cyclic stressing; its Meyer index and strain-hardening exponent are high. Despite the high indentation hardness and the internal stresses it contains, fresh martensite work-hardens during plastic deformation although work-softening could have been expected to occur in these conditions.

Tempering up to about 300C causes the strain-hardening properties to decrease progressivley and the elastic limit to rise. The impact fracture energy and ductility at sub-zero temperatures fall to a minimum but they can be improved or otherwise altered by prior cold-working at room temperature.

Most of these facts cannot be explained or accounted for if the commonly held view of virgin martensite being inherently very hard is accepted as an axiom. However, they all find their natural place in an integrated picture if as-quenched steel is visualized as being relatively soft but capable of rapid work-hardening when deformed. Tempering below 300C is assumed to produce a hardening effect roughly similar to that of cold-working.

A working hypothesis is developed in the paper based on the above premise and incorporating a Cottrell-type mechanism involving locking of dislocations by migration of solute carbon atoms. This is then applied to account for various peculiar aspects of the mechanical behavior of hardened and tempered steel.

From author's summary

2152. **Noren, T. M., The nominal cleavage strength of steel and its importance for welded structures,** *Trans. N. E. Cst. Instn. Engrs. Shipb.* **73,** 2, 87–112, Dec. 1956.

A certain property of steel called the "nominal cleavage of strength" can be determined by means of tensile test pieces on the edges of which a brittle alloy has been welded. On exposing these test pieces to an increasing tensile stress, cracks are continuously formed in the brittle layers of welding. At a certain critical stress a fracture will be initiated at one of the sharp crack fronts. A characteristic property of a steel, the nominal cleavage strength is defined as the highest nominal tensile stress a steel can withstand in the presence of a crack without the initiation of fracture at the crack front. The nominal cleavage strength decreases continuously as the temperature decreases just as the conventional yield point increases continuously with decreasing temperature. If curves of these strengths are drawn, the point of intersection would appear to be a transition temperature for the steel, defined as the temperature above which plastic deformation can occur in a large volume of material despite the presence of a crack, but below which only minor local plastic deformation is possible immediately in front of the crack. By means of the testing method called "NC-testing" (NC = nominal cleavage), results have been obtained that show a certain correlation to the results of impact tests as well as to those of other brittle-fracture tests, e.g., Tipper, van der Veen, and others, Moreover, the critical stresses for initiation and propagation of brittle fractures are shown by means of NC-curves as well as the influence of residual welding stresses. It is also shown that the quality of a steel with regard to its brittle-fracture tendency cannot be simply expressed by an impact transition temperature as the critical stresses quoted above are not directly connected with the position of this temperature.

From author's summary

2153. **Masumoto, H., Saito, H., Kono, T., and Sugai, Y., Thermal expansion coefficient, rigidity modulus and its temperature coefficient, of the alloys of iron, nickel, cobalt and chromium, and relations of super invar to stainless invar and of elinvar to co-elinvar,** *Sci. Rep. Res. Inst. Tohoku Univ., Japan* (*A*) **8,** 6, 471–483, Dec. 1956.

2154. **Suchoversky, I. E., Selection of testing locations in aluminum die forgings,** *Aero. Engng. Rev.* **16,** 1, 29–34, Jan. 1957.

Experimental evidence shows the high dependence of the level of mechanical properties on the angle between testing direction and grain axes. Mechanical property tests must be carried out strictly in relation to the grain axes in order that representative, comparable, and predictable results may be obtained regardless of the shape and type of the forging. From author's summary

2155. **Jones, D. T., Variations in the strength of aluminum alloy sheet,** *Aero. Res. Counc. Lond. curr. Pap.* 229, 9 pp. + 1 fig., 1956.

In the design of aircraft structures, allowance is made for variation in the material strength of sheet, but the thickness of the sheet is usually assumed to be constant at the nominal value for the gage used.

Thickness variation may appreciably affect the tensile strength of nominally identical pieces of sheet, especially when the tolerance range in thickness is wide. A method is given in this note

for calculating the distribution of strength when the mean and scatter of material strength and the mean and scatter of thickness of pieces are known. Expressions are given for the mean and scatter in strength of pieces and, for those cases where the distribution of the strength can be taken as normal, design values can readily be deduced from the expressions.

From author's summary

2156. Chernyagin, B. M., Determination of the temperature coefficient of the elasticity modulus of spiral springs (in Russian), *Zavod. Lab.* **21**, 1, 89–92, 1955; Rev. no. 1194, *Ref. Zh. Mekh.* 1956.

An arrangement is described for determining the temperature relationship of the elasticity modulus of the material of spiral springs. The equipment measures the change in the period of oscillation of the system formed by a balance and the test spring, in relation to the temperature of the thermostat containing the balance and the spring. Equations are given for calculating the temperature coefficient from the measured values of the period of oscillation of the balance. Evaluation of the accuracy of the said equipment gave an error of 23.9%. Means for considerably reducing the error are described. L. E. Andreeva, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2157. Rokhlin, I. A., The strength of ceramic building materials under impact loading (in Russian), *Sb. Novoye v stroit. tekhnike, Kiev, Izd-vo Akad. arkhitektury SSSR* no. 5, 22–31, 1954; Rev. no. 1844, *Ref. Zh. Mekh.* 1956.

Results are given of impact bending tests on samples of two batches sawed from the walls of hollow building bricks. One batch had been made of spondylic clay, the other of spondylic and Chasov'yarsk clay with loess. The dimensions of the test samples were 30 × 12 × 100 mm. The tests were made with a pendulum hammer. The specific work of fracture in impact bending of ceramic products varies within narrow limits (between 2.10 to 2.75 kg cm/sq cm).

Fatigue tests were also made on ceramics in cubes of 1-cm side, under vertical compression.

The testing method described can be useful in disclosing structural defects arising during the manufacture of ceramic goods.

Courtesy of Referativnyi Zhurnal A. S. Dmitriev, USSR
Translation, courtesy Ministry of Supply, England

2158. Anonymous, How to make plastic springs, *Amer. Machinist* **100,** 22, 154–156, Oct. 1956.

Springs formed from glass-fiber reinforced resin have many desirable mechanical and decorative properties for a wide range of applications. Until a practical technique for mass-producing these springs was developed by the National Bureau of Standards in work sponsored by the Army Ordnance Corps, there was no satisfactory way of making them. Paper gives the recommended procedure. From summary

2159. Treloar, L. R. G., Large elastic deformations in rubber-like materials, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 208–217; Berlin, Springer Verlag, 1956.

Short expository paper describes and compares theories and experiments. Meyer statistical theory rests on greater probability of kinked states of long-chain molecules, stretched state having no more internal energy than unstretched state. It leads to stored energy $W = C_1(I_1 - 3)$, C_1 a constant proportional to temperature, $I_1 - 3$ a first strain-invariant. Mooney form is $W = C_1(I_1 - 3) + C_2(I_2 - 3)$, $I_2 - 3$ a second strain-invariant. Comparison is by Rivlin's general stress-strain formulas, with experiments of author, and of Rivlin and Saunders. Conclusion is "As a first approximation, and particularly where simplicity of calculation is an important consideration, the behavior of a rubber may be represented by the 1-constant stored-energy function derived from the statistical theory. If a closer approximation is required, the empirical 2-constant formula of Mooney is likely to be adequate in most practical cases. Only in special cases is it likely to be necessary to introduce higher approximations, and in such cases a rather elaborate investigation of the properties of the particular material under consideration will be required." J. N. Goodier, USA

2160. Smirnov, V. M., The structure and mechanical properties of asphalt-concrete (in Russian), *Trudi Khar'kovsk. avtomob.-dor. in-ta* no. 17, 59–68, 1954; Rev. no. 1799, *Ref. Zh. Mekh.* 1956.

Results are given of the examination of the variation of shear deformation in time with unchanged stress for bitumen BN2 and bituminous mixtures with lime and quartz sand. Bibliographical references cover 15 sources. N. N. Kulakov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2161. Ikeda, S., and Okajima, S., Stress-strain curve of a fibre of irregular cross-sectional area, *Mem. Fac. Technol., Tokyo Metrop. Univ.* no. 6, 79–92, 1956.

The load-elongation curve of a fiber with nonuniform cross-sectional area along its length gives an apparent Young's modulus different from that for a uniform fiber. Authors show mathematically how to correct for this effect when the variation of area with length is known. Specifically, the use of the harmonic mean of the area in place of the arithmetic mean gives a much better estimate of the modulus. Experiments on rabbit hair and on wool show that some of the fiber-to-fiber variability found in the elastic properties of animal fibers is removed by taking into account the nonuniformity in cross-sectional area, but that there still remains an intrinsic variability. D. J. Montgomery, USA

Plasticity, Forming and Cutting

(See also Revs. 2116, 2120)

Book—2162. Durr, A., and Wachter, O., Hydraulic drives and controls of machine tools [Hydraulische Antriebe und Druckmittelsteuerungen an Werkzeugmaschinen] 3rd ed., München, Carl Hanser Verlag, 1954, 217 pp., 257 figs. DM 12.50.

This somewhat enlarged edition deals in clearly outlined chapters with oil-circulating systems, characteristics of driving oils, driving oil pumps, hydraulic motors and gears, hydraulic machine elements such as valves, choking equipments, control mechanisms, cylinders, pistons, pipe lines, their setting up and working, and finally with complete hydraulic drives of machine tools for different tasks.

Book discusses the principles of working of many different devices, gives numerous detailed construction drawings, deals with the working process of apparatus and the aspects of operation. It takes into consideration especially the requirements of the planning and plant engineers. The book is of great value for them because of the many detailed drawings of constructions and excellent photographs. It contains some interesting characteristic diagrams, too. The book omits intentionally the more inclusive discussion of theoretical matters. It is also suitable for introducing engineers and students to the subject.

The arrangement of the material is skillfully and logically done; it facilitates the survey and reading of it. This is a well-done book, and its style is simple and clear.

G. Pattantyus, Hungary

Book—2163. Reshetov, D. N., Strength calculations for machine tools under varying loading conditions [Raschet detalei

stankov na prochnost' primenyayushchikhsya rezhimakh nagruzki], Moscow, Izd-vo Akad. Nauk SSSR, 1954, 5-47; Rev. no. 1730, *Ref. Zh. Mekh.* 1956.

Suggestions are made for considering fluctuations in loading conditions in the calculation of the durability of elements of machine tools for metal-working.

From accumulated statistical material on working experience with machine tools, recommendations are made for the determination of rated working conditions.

A method of calculation devised by the author is put forward for the mechanical endurance of belt drives and the abrasion life of chain drives. Z. P. Davlov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2164. **Schmidt, A. O., Ham, I., Phillips, W. I., and Wilson, G. F., Ceramic and carbide tool performance tests, Part I,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-218, 19 pp. + 24 figs.

2165. **Vasiliev, M. V., The evaluation of tool materials from repeated-impact tests** (in Russian), *Zavod. Lab.* **20,** 3, 337-338, 1954; Rev. no. 1845, *Ref. Zh. Mekh.* 1956.

When evaluating the suitability of tool materials, author suggests determining their resistance to repeated impact. Test results are given for the repeated-impact testing of several brands of high-speed (free-cutting) cast steels.

D. I. Gol'tsev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2166. **Bernutat, P., Dynamic forces in tubular ball mills** (in German), *ZVDI* **98,** 33, 1843-1847, Nov. 1956.

Calculation of the dynamic forces in tube mill filled during service shows that they do not vary considerably from the static forces. Therefore known calculations based on the load on a stationary mill can be maintained for rotary mills of larger dimensions. P. Grodzinski, England

2167. **Clorite, P. A., and Reed, E. C., Influence of various grinding conditions upon residual stresses in titanium,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-44, 4 pp.

Grinding conditions may be expected to affect residual surface stresses from any particular grinding operations. Stresses were measured in titanium test bars, surface-ground with various wheels, speeds, grinding fluids, down-feeds, and crossfeeds. Results suggest that, with suitable precautions, titanium alloys may be ground under either "near-normal" or "low-normal" conditions with acceptable grinding ratios and with low residual stresses. From authors' summary

2168. **Harrington, J., What causes grinding stress?** *Amer. Machinist* **100,** 22, 124-126, Oct. 1956.

For some time, it has been recognized that any machining operation produces a work-hardened layer equal to 50% of depth of cut. In grinding, however, high temperatures generated at the work-wheel point of contact produce stresses of considerable magnitude. Because grinding is a finishing process, reduction of these stresses becomes a matter of concern. Causes and elimination are discussed. From author's summary

2169. **Duran, P. J., Ultrasonic impact grinding,** ASME Semiann. Meet., Cleveland, Ohio, June 1956. Pap. 56-SA-47, 10 pp.

2170. **Grigoriev, B. V., On the value of the internal residual stresses in the rolling of blanks for membranes** (in Russian), *Trudi Mosk. aviats. tekhno. inta* no. 22, 111-116, 1954; Rev. no. 1633, *Ref. Zh. Mekh.* 1956.

An attempt is made to determine theoretically the residual stresses in a strip during rolling, in relation to the value of the roll pressure. On the basis of a series of assumptions, the deformation of the fibers in the rolling direction is approximately determined by Hooke's law. V. A. Lomakin, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Hydraulics; Cavitation; Transport

(See also Revs. 2162, 2325, 2363)

2171. **Escoffier, F. F., Graphical determination of water-surface profiles,** *Proc. Amer. Soc. civ. Engrs.* **82,** HY 6 (*J. Hydr. Div.*), Pap. 1114, 13 pp., Dec. 1956.

Author takes the results obtained by Bakhmeteff as a basis of his work and, changing a variable, transforms his functions. He deduces from them a very simple graphical method which translates the classical equation:

$$L_{12} = (Y_0/S)\,[\eta_2 - \eta_1 - (1 - \beta)\,(B_2 - B_1)]$$

On adaptation, this method can be applied to other backwater functions.

It would be desirable for author to give applications of his method to particular cases which have been experimentally confirmed. L. Escande, France

2172. **Pode, L., A rapidly converging solution of the conformal mapping problem of hydrodynamics,** *David W. Taylor Mod. Basin Rep.* 1041, 17 pp., July 1956.

A method of computing the conformal transformation which maps the region exterior to a simple closed boundary curve onto the exterior to a circle is discussed. The method involves successive conformal transformations under which the boundary curve becomes more and more circular. Convergence properties are discussed and an explicit first-order solution is given for the near circle case.

From author's summary by A. van Heemert, Holland

2173. **Prusov, V. M., The precise integration of the equations of unsteady slowly varying motion of a liquid in certain parabolic waterways** (in Russian), *Uchen. Zap. Karelo-Finskogo Univ.* **3,** 4, 63-76, 1954; Rev. no. 198, *Ref. Zh. Mekh.* 1956.

A precise solution has been obtained for the differential equations of unsteady, slowly varying motion in waterways, the transverse section of which is bounded by the parabolas with the characteristics $k = 2/(2m - 1)$ $(m = 1, 2, \ldots.)$ in the absence of resistance. Author starts from equations given in the monograph of S.A. Khristianovich [see Symp. "Certain new problems of the mechanics of a dense medium," Izd-Vo.Acad.Sci.USSR 1938] and uses the method of integrating similar equations of the problem of undimensional motion of a compressed gas [see Landau, L.D., and Lifshits, E.M., "Mechanics of dense media," Gostekhizdat, 1954]. This method, based on Legendre equations, is used for solving a particular problem: an investigation is made of the unsteady motion in a semi-bounded channel, the cross section of which is bounded by the parabola $y = ax^2$. The channel is closed off by a thin vertical barrier which is destroyed at the initial instant of time, while the upper water is of limited extension.

V. A. Karpychev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2174. **Fandeev, V. V., On the peculiarity of the formulas of critical deviation** (in Russian), *Nauk Zap. Mosk. Inst. Inzh. Bodn. Kh-Va* no. 18, 53-68, 1955. Rev. no. 200, *Ref. Zh. Mekh.* 1956.

The relationships of the critical deviation in trapezoidal (including rectangular and triangular) beds and beds of circular section are examined in detail. The Chezy coefficient is taken from N.N. Pavlovsky's data. Auxiliary tables and graphs for calculating the critical deviations are given, and the relationship between the critical deviation and the Froude coefficient is indicated. Certain practical recommendations are given for using rapid flows with a critical deviation, and examples of calculations are given. G. K. Mikailov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2175. Kabakov, M. M., New formulas for the calculation of water flow in the presence of actual losses in channels with active branches (in Russian), *Trudi' Inta vodnogo kh-va i energetiki Kirgh. filiala Akad. Nauk USSR* no. 1, 17–25, 1954; Rev. no. 821, *Ref. Zh. Mekh.* 1956.

An examination of the calculation of the flow of water Q_p in a channel (for the determination of filtration losses), in the presence of branches and discharges arranged along the channel, and a series of equations, founded on determination of the weighted means of the flow values in sections of the channel; whereof Eq. (14)

$$Q_p = \beta \left(Q_B - \sum Q_0 \frac{l_0}{L} + \sum Q_c \frac{l_c}{L} \right)$$

may be quoted, in which Q_B = flow in the upper section of the channel; Q_0, Q_c flow in the branches and discharges; l_0, l_c their distance correspondingly from the lower calculated section; L length of the calculated section, for which Q_p is determined.

The coefficient β considers the losses along the length of the channel, and has the limiting values $0.97 \leqslant \beta \leqslant 1.00$, depending on the impermeability of the soil, arrangement of the branches along the length of the channel, and the said length; author gives a table for determining β. S. F. Aver'yanov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2176. Manhajm, J., and Sweeney, D. C., An investigation of hydraulic lock, *Instn. mech. Engrs. Proc.* **169,** 42, 16 pp., 1955.

Theoretical and experimental investigation of hydraulic lock in piston-type control valves. Hydraulic lock is a hydrodynamic effect arising when, owing to machining imperfections in the piston lands or cylinder bore, the flow of fluid in the clearance space is either diverging or converging. For the experiments a cylinder of uniform bore was used in conjunction with dumbbell-shaped pistons having lands of such form as to give various taper-clearance ratios. Pressure tappings at a number of points in the cylinder wall allowed the pressure distribution in the clearance space to be measured. A spring balance was used to measure locking force. The coefficient of static friction between piston and cylinder was obtained by placing the cylinder in a horizontal position and measuring the frictional forces for various normal loads. Coefficient of static friction was found to be 0.24.

R. Schnurmann, England

2177. Cohen, H., and Gilbert, R., Two-dimensional, steady, cavity flow about slender bodies in channels of finite breadth, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-29, 7 pp.

The steady, cavitating flow past slender symmetrical bodies placed in a solid-wall channel is studied by means of the linearized theory of Tulin. The free-boundary condition is linearized, and boundary conditions are applied on the line of symmetry of the flow in analogy with thin-airfoil theory. A singular integral equation formulation of the boundary-value problem is obtained and can be solved to yield expressions for cavity length, maximum cavity width, and drag coefficient as functions of the cavitation number and the channel breadth. These expressions are given for an arbitrary body and evaluated for the case of a wedge.

From authors' summary by H. H. Anderson, Scotland

2178. Plesset, M. S., On physical effects in cavitation damage, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955; Berlin, Springer Verlag, 1956; 218–235.

Author gives first results of experiments on specimens made of various materials, exposed to cavitation damage. He produced acoustic wave pattern in beaker usually containing distilled water and, sometimes, toluene. Waves have point of resonance in center of beaker bottom, where cavitation is generated on specimen. Effects, observed with x-ray, show cold work on plane surfaces exposed to cavitation.

When specimen has small cylindrical tip, a hole is produced in tip. Hole diameter is assumed by author as measure of damage. Results prove that damage is due to physical effect and is related chiefly to hardness, secondarily to tensile strength and modulus of elasticity of materials. Finally, author tells how he measures stress, induced by cavitation, by means of photoelasticity.

Reviewer believes that methods employed by author are very interesting and are such as to supply valuable information about cavitation. M. Viparelli, Italy

2179. German, V. L., and Azbel, M. Ya., On the hydrodynamics of a cavitating fluid (in Russian), *Dopovidi Akad. Nauk USSR* no. 2, 115–118, 1954; Rev. no. 810, *Ref. Zh. Mekh.* 1956.

The motion of a binary fluid is examined, consisting of a liquid which contains gas bubbles. This mixture is substituted by a homogeneous incompressible fluid with a density corresponding to the mean density of the binary fluid. The gas component is considered as in the isothermal state. The velocity of acoustic propagation in the binary fluid is examined, and problems analyzed of the flow of such a fluid around a thin airfoil, and of the flow through a two-dimensional diffuser. Authors identify the flow of a binary fluid with the case of a cavitational flow.

The substitution of a binary fluid by a homogeneous incompressible fluid is not new; analogous results have already been published [J. Ackeret: "Technische Mechanik und Thermodynamik," I, 1930; G. Heinrich: *ZAMM* **23,** 1943; L. A. Epstein: *Doklady Akad. Nauk USSR* **49,** no. 6 1945; Trans. CAHI, no. 584, 1946].

If such theories are to be applied to ordinary cavitation flows, allowance must be made for the phenomena of gas segregation from the mixture (cf. Epstein, supra).

L. A. Epshtein, USSR

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INCOMPRESSIBLE FLOW; LAMINAR; VISCOUS

(See also Revs. 2171, 2173, 2203, 2212, 2216, 2217, 2218, 2221, 2222, 2224, 2253, 2254, 2294, 2298, 2308, 2317, 2350, 2351)

2180. Starkey, T. V., Viscosity and action, *Brit. J. appl. Phys.* **7,** 12, 448–450, Dec. 1956.

Hamilton's principle is used to show that, for the laminar flow of a given volume of liquid through a tube, the product of the energy dissipated and the time is a minimum. This condition requires a parabolic velocity distribution in laminar flow through tubes. It is also shown that the nonturbulent flow of a fluid showing shear dependence is not laminar, and that it resembles in many fundamental respects the turbulent flow of a Newtonian

liquid. These results follow from the recognition of apparent viscosity as a direct measure of the action per unit volume associated with a given change in the configuration of the elements of which the fluid may be imagined to consist.

From author's summary by Joseph S. Marcus, USA

2181. Ovchinnikov, O. N., The influence of the velocity profile at the entry on the working of diffusers (in Russian), *Trudi Leningr. Politekh. in-ta* no. 176, 175–188, 1955; Rev. no. 1518, *Ref. Zh. Mekh.* 1956.

The development is examined of the flow of a viscous fluid on a conical diffusor with an arbitrary, axially symmetrical velocity profile at the entry, on the basis of the same approximation formulas as have been used in the solution of the uniform case of this problem in the book of S. M. Targ ["Fundamental problems of the theory of laminar flows", Moscow-Leningrad, GITTL, 1951]. The results of the numerical calculations are presented in the form of curves for convex, regular, and concave velocity profiles at the entry. The experimental results are given for the case of two diffusors, conical and curvilinear, respectively, at Reynolds' numbers of 250,000 to 280,000. It is noted that the flow pattern in the diffusor agrees well, qualitatively, with the theoretical conclusions, despite the fact that this theory refers to laminar conditions, while the experiments were made in the presence of turbulence. N. A. Slezkin, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2182. Loitsiansky, L. G., Radial slot flow in an identical ambient fluid (in Russian), *Trudi Leningr. politekh. in-ta* no. 5, 5–14, 1953; Rev. no. 880, *Ref. Zh. Mekh.* 1956.

A theory is developed for an axially symmetrical, laminar, submerged flow of an incompressible fluid, issuing from a radial slot. The general case is examined of a flow with relative rotation about the axis of the slot, for relatively high values of the Reynolds number; when the usual assumptions of the theory of laminar flow are permissible, the equations of motion of the viscous fluid and the continuity condition are referred to a corresponding system of the equations of an asymptotic, laminar boundary flow, with the usual boundary conditions. In addition, the conditions of preservation of quantity of motion and moment of the quantity of motion are retained.

The stream function of the meridional flow and the rotatory component of the velocity are expanded by the author in series, by negative powers of the distance from the slot flow source.

In the resulting solution, the radial and rotatory components of the velocity reach a maximum in the plane of symmetry of the jet and decrease with increasing distance from the source (the first is inversely proportional to this distance; the second, inversely proportional to the square of the distance). Assuming for the particular case that the moment of the quantity of motion is zero, the author obtains the solution for the untwisted, laminar, radial slot flow.

Author further shows that, on the basis of Prandtl's new theory of free turbulence, the solution of the problem of the laminar jet can be extended to the case of the turbulent jet, since in this case the coefficient of "turbulent viscosity" will be found constant for the whole region of the flow.

Author deals separately with the case of a conical, radial slot flow, and shows that, if expansion of the velocities by negative powers of the distance from the source is confined to the terms with x^{-2}, the fundamental equations obtained will be the same as for the simple, radial slot flow. The difference in the solution for the conical jet is only that in the expressions for the quantity of motion and the moment of the quantity of motion, multipliers will appear depending on the angle of conicity of the jet. An essential characteristic of the conical jet is the pressure drop within the volume thereof.

Courtesy of Referativnyi Zhurnal G. N. Abramovick, USSR
Translation, courtesy Ministry of Supply, England

2183. Seddon, J., and Haverty, L., Some tests on the spread of velocity in a cold jet discharging with excess pressure from a sonic exit into still air, *Aero. Res. Counc. Lond. curr. Pap.* 246, 6 pp. + 9 figs., 1956.

The spread of the half-velocity circle in a jet discharging with excess pressure from a length of parallel pipe into still air has been examined over the range 40 to 200 diameters from the exit. Jet pressure ratios (outside static pressure ÷ jet total pressure) were from 0.479 to 0.042, corresponding to isentropic Mach numbers from 1.08 to 2.72.

It is found that rates of spread are not greatly different from that for a subsonic jet. The effective exit of an under-expanded jet is, however, displaced some distance downstream of the actual exit. For a jet of isentropic Mach number 1.51, the effective exit position is about 8 diameters downstream, and the half-velocity circles lie on a cone of semiangle 5.7° from the center of the effective exit. From authors' summary

2184. Pataraya, N. N., On the stability of the wedge motion of spherical bodies in a fluid (in Russian), *Trudi Tbilis. un-ta* no. 54, 7–18, 1954; Rev. no. 1455, *Ref. Zh. Mekh.* 1956.

Author examines the flow of a perfect, irrotational fluid about a system of spheres of identical diameter the centers of which are located on the sides of a wedge. The interacting forces are calculated, and certain conditions investigated, of the stability of the wedge configuration of the spheres with reference to perturbations corresponding to abrupt acceleration or retardation of individual spheres. N. N. Moiseev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2185. Takaisi, Y., The drag on a circular cylinder placed in a stream of viscous liquid midway between two parallel planes, *J. phys. Soc. Japan* **11,** 10, 1092–1095, Oct. 1956.

Author carries out an analytical determination of the drag on a circular cylinder in pure viscous flow between two parallel planes. Two previous treatments, by Barstow, Cave & Lang in 1921, and by Harrison in 1923, produced quite different results. The present method based, like the others, on Stokes' equations of motion produces a result in close, though not exact, agreement with Harrison's. No correlation with experimental work is given.

M. A. Mayers, USA

2186. Bass, J., On the solution of equations of incompressible viscous fluids in unsteady flow (in French), *C. R. Acad. Sci. Paris* **243,** 3, 229–230, July 1956.

Paper studies existence of solutions in a bounded domain D with initial velocity given in D and velocity *and pressure* given on fixed boundary of D for time $t > 0$. Author notes that, for Navier-Stokes equations, velocity and pressure cannot be given independently on the boundary, and hence his study does not seem to pertain to any actual fluid flow.

A. E. Bryson, Jr., USA

Compressible Flow, Gas Dynamics

(See also Revs. 2204, 2205, 2206, 2207, 2209, 2214, 2225, 2231, 2233, 2237, 2256, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2276, 2281, 2291)

2187. Kaeppeler, H. J., Effect of variation of design parameters, especially the wing area, on the maximum deceleration and skin temperature of re-entry missiles (in German), *Z. Flugwiss.* **4,** 12, 382–388, Dec. 1956.

Analytical expressions are obtained starting with equations of motion published previously [H. J. Kaeppeler and M. E. Kübler, Fifth International Astronautical Congress, Aug. 5–7, 1954]. Winged missile is assumed to glide at supersonic speeds with constant angle of attack. Heat transfer is assumed to take place on a conical nose. Solution emphasizes (a) effect of variation of lift characteristics compared with variation of drag characteristics, and (b) effect of a redistribution of aerodynamic forces and missile weight. E. L. Knuth, USA

2188. Van Dyke, M. D., The similarity rules for second-order subsonic and supersonic flow, *NACA TN* 3875, 20 pp., Jan. 1957.

The similarity rules for linearized compressible flow theory are extended to second order. It is shown that any second-order subsonic flow can be related to "nearly incompressible" flow past the same body, which can be calculated by the Janzen-Rayleigh method. From author's summary by J. R. Baron, USA

2189. Clarke, D. A., and Gamble, H. E., Choking effects and some Reynolds number effects on the Mach number distribution round a two-dimensional aerofoil in the RAE 10-ft × 7-ft high-speed tunnel, *Aero. Res. Counc. Lond. Rep. Mem.* 2912, 30 pp., 1956.

A two-dimensional airfoil of NACA 0015 section was tested at zero incidence in the Royal Aircraft Establishment 10-ft × 7-ft high-speed wind tunnel and measurements were made of

(*a*) static pressure on the airfoil surface at Reynolds numbers of 1.4×10^6 to 5.5×10^6.

(*b*) static pressure on the airfoil surface, on the tunnel walls, and in the stream between the airfoil and the walls at $R = 2.8 \times 10^6$.

All the tests were made at Mach numbers of 0.7 upwards and were continued past the choking Mach number of 0.764 until either the maximum permissible fan speed was reached or the maximum available power was being used.

The results showed that the choking Mach number was about 0.764 at Reynolds numbers from 1.4×10^6 to 2.8×10^6. Above $M = 0.760$, the development of the supersonic region towards the walls was extremely rapid in terms of tunnel Mach number. At $M = 0.761$ the sonic line was only about half-way out to the tunnel walls and at $M = 0.764$ it had reached them.

Before and during choking quite large changes in the airfoil pressure distributions were produced by varying the Reynolds number. At $M = 0.73$ and 0.75 the shape of the pressure distribution curves indicated the possibility of the λ-shock at the lower Reynolds numbers and a single shock at the higher Reynolds numbers. From authors' summary

2190. Keune, F., Summarizing representation and broadening of the equivalence rule for transonic flow (in German), *Dtsch. Versuchsanstalt Luftfahrt E. V.* no. 8, 74 pp., July 1956.

In first part of paper, the principle of comparing the flow about bodies with the same cross-sectional area distribution is presented, and the equivalence rule, which includes as an application the area rule of Whitcomb, is formulated. Special attention is devoted to the theory, valid for transonic flow, and the incorporation of the results of this theory in those cases valid for sub- and supersonic flow. The "coke-bottle" form, given to the body of wing-body combinations, is considered as a consequence of the equivalence rule and also as a device appearing useful from other aerodynamical considerations.

In the second part, the theoretical results of former publications of K. Oswatitsch and the author are presented, in order to provide a theoretical base for the determination of the flow about a wing-body combination and of its most favorable form (minimal drag).

The limits of the theory are given, and many still unsolved questions, especially in the transonic speed range, are mentioned. Author has not intended to give new results, but gives, rather, a critical review and a summary of already published results.
E. M. de Jager, Holland

2191. Page, W. A., Experimental determination of the range of applicability of the transonic area rule for wings of triangular plan form, *NACA TN* 3872, 22 pp., Dec. 1956.

2192. Meyer, R. E., On supersonic flow behind a curved shock, *Quart. appl. Math.* **14,** 4, 433–436 (Notes), Jan. 1957.

A solution for flow behind a curved shock attached to the nose of a sharp-edged cylindrical body immersed in a uniform supersonic stream is presented. Solution accounts to a first approximation for entropy gradients and vorticity downstream of the shock. Characteristic equations of steady, two-dimensional, inviscid supersonic flow are used, and assumption of a constant characteristic parameter α along streamlines is made. Results provide solution of indirect problem of determining shape of body upstream of a "minus" Mach line on which the flow is prescribed. Equations for solution of direct problem of determining the flow when shape of the body is prescribed are also given.
M. Morduchow, USA

2193. Tobak, M., and Wehrend, W. R., Stability derivatives of cones at supersonic speeds, *NACA TN* 3788, 43 pp., Sept. 1956.

Author determines both static and dynamic stability derivatives on circular cones in supersonic flow using solutions of the potential flow equation. Two approaches are made. In the first, the first-order wave equation is applied with exact boundary conditions. In the second, the first-order cross flow potential is combined with the second-order axial flow potential. The approximations are justified by the good agreement between present results and those derived from the exact theory of yawed cone flow in the static case.

To cover higher Mach numbers and bodies of more general shape, stability derivatives are also calculated by Newtonian impact theory. Marshall Holt, USA

2194. Bertram, M. H., Tip-bluntness effects on cone pressures at M = 6.85, *J. aero. Sci.* **23,** 9, 898–900 (Readers' Forum), Sept. 1956.

2195. Rodriguez, A. M., A study of optimum spatial lift distributions at supersonic speeds, *Douglas Aircr. Co. Rep.* SM-19292, 40 pp., Nov. 1955.

This is a continuation of similar older papers by the same author. By way of mathematical idealization and to provide an academic background or yardstick, the following is determined analytically: the distribution of the lift through space under various limiting conditions that make the drag a minimum. Considerable space is given to pertinent comment regarding the mathematical details of these computations.

This report is intended only for mathematicians specializing in such questions. It does not appear that a broad, simple, and forceful result or theorem is arrived at. In that respect the reviewed paper differs from reviewer's 1921 paper on induced drag cited by the present author. The reviewed investigation is a remote offshoot of said 1921 paper. M. M. Munk, USA

2196. Bulakh, B. M., Theory of nonlinear conical flow (in Russian), *Prikl. Mat. Mekh.* **19,** 4, 393–409, July/Aug. 1955.

Author considers irrotational conical flows under the assumption that any shocks that occur are so weak that vorticity and variations in entropy are negligible. A conical flow field adjacent to a region of supersonic flow must be a simple wave, in which one family of characteristic surfaces is composed of planes. There is an extensive discussion of the relation of the envelope of these

planes to a parabolic surface of the governing partial differential equation.

The results are applied to an attempt to determine the qualitative nature of a symmetrical conical flow at moderate angle of attack over a plane wing with sweptforward supersonic leading and trailing edges. On the upper (lower) surfaces there appear the expected expansions (plane shocks) at the leading edges, followed by regions of uniform flow. Efforts to supplement these by the required simple wave patterns lead to contradictions which force the author to conclude that additional shocks occur in the disturbed flows on each side of the wing. Within these shocks he formulates boundary-value problems of elliptic type which he has solved by relaxation methods in a particular case.

J. H. Giese, USA

2197. Zienkiewicz, H. K., On an approximate method of calculating pressures on non-lifting head shapes at supersonic speeds, *Aero. Quart.* **6,** 1, 31–45, Feb. 1955.

Slender-body theory is used to derive the ogive of curvature approximation for very slender, pointed, convex head shapes at supersonic speeds. Results of application of this approximation, together with the λ-method for circular arc ogives, to a variety of non-slender head shapes show very good agreement with the method of characteristics, van Dyke's second-order theory, and experiment. Good agreement with the method of characteristics and with experiment is obtained even in cases when the stagnation pressure losses across the nose shock wave are not negligible.

From author's summary

2198. Britton, D., and Davidson, N., Shock waves in chemical kinetics. Rate of dissociation of molecular bromine, *J. chem. Phys.* **25,** 5, 810–813, Nov. 1956.

The rate of dissociation of molecular bromine in argon-bromine mixtures has been measured in a shock tube and the rate constants for the reaction $Br + Br + M \xrightarrow{k_R} Br_2 + M$, in the temperature range 1400–2700 K, computed. The data are not sufficiently accurate to reveal the temperature coefficient of k_R. However, comparison of the average high temperature result, $k_R = 3.4 \times 10^8$ liter^2 mole^{-2} sec.$^{-1}$ at 1600 K, with the room temperature flash lamp result $k_R = 2.5 \times 10^9$, shows clearly that dk_R/dT is negative. Experiments were performed with bromine: argon ratios of 0.01 to 0.10; the efficiency of Br_2 as M, the third body for the recombination of bromine atoms, is not greater than 8 times that of argon. The agreement of the results of this investigation with those of an independent shock-tube investigation by Palmer and Hornig is gratifyingly good.

The extinction coefficients of bromine at 436 mμ and 487 mμ were measured as a function of temperature.

From authors' summary

2199. Prosnak, W., Shock wave in a two-dimensional radial gas flow, *Arch. Mech. stos.* **8,** 4, 617–645, 1956.

The principal aim of this paper is an analysis of the influence of viscosity and heat conductibility upon the distribution of velocity or other gas parameters in a two-dimensional symmetric radial flow [a source or a sink] in the vicinity of the point corresponding to the critical velocity. A system of four basic equations describing a flow of this kind is reduced to a differential equation of the first order, which is analyzed by means of the qualitative theory of differential equations.

If the gas viscosity alone is taken into consideration, a range of theoretically possible types of flow is obtained. The corresponding velocity distributions are represented graphically.

The behavior of gas parameters is investigated and regions of flows having no physical sense are determined.

If heat conductibility is the only quantity considered, several theoretical types of flow are obtained.

A. Jakubowski, Poland

Wave Motion in Fluids

(See also Rev. 2320)

2200. Mogi, K., Experimental study of diffraction of water surface waves, *Bull. Earthq. Res. Inst., Tokyo Univ.* **34,** 3, 267–277, Sept. 1956.

Authors utilize a small wave tank to study the diffraction of simple sinusoidal water surface waves caused by semi-infinite plates, slits between two semi-inifinite plates, plates of finite length, and by cylinders. The wave tank is 120 cm long, 100 cm wide, and 10 cm deep, in which plane sinusoidal waves of 5-cm length, 0.17-sec period, and 0.1-mm height are generated. The diffraction pattern caused by the various obstacles employed in the study is determined optically, using photographic techniques. Quite remarkable agreement is obtained between observation and Sommerfeld's optical theory of diffraction, even for the case of plates of short length, slits of small size, and cylinders of radius of the same magnitude as the wave length.

Reviewer believes results of this paper can only be applied to ideal case of sinusoidal surface waves. Waves on a natural body of water are of complex shape, not at all represented by a simple sine wave, and probably do not behave according to the Sommerfeld theory.

The English in this article is quite good, when compared to many attempts by Japanese investigators.

D. W. Pritchard, USA

2201. Shaitan, V. S., An instrument for measuring wave lengths in laboratory conditions (in Russian), *Trudi N.-i. in-ta. osnovaniy. i. fundamentov* no. 25, 129–131, 1955; Rev. no. 1498, *Ref. Zh. Mekh.* 1956.

An instrument is suggested for measuring wave lengths in regular wave motion under laboratory conditions.

Two pairs of electrodes immersed in water represent two transmitters of the resistance type, the conductivity whereof varies with the perturbations of the free surface. These transmitters are connected in an electrical bridge circuit, regulated in such manner that the zero readings of the galvanometer correspond to equal water levels above the points of immersion of each pair of electrodes.

The wave length is determined from the distance between such electrodes.

The accuracy attainable in measuring wave lengths with the suggested instrument is indicated.

S. S. Voit, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Turbulence, Boundary Layer, etc.

(See also Revs. 2219, 2248, 2272)

2202. Okamoto, T., Note on Wada's method of solving the laminar boundary layer equations, *Bull. Tokyo Inst. Technol. (B),* no. 1, 25–26, 1956.

Author discusses the validity of the two assumptions Wada made in order to solve the equations for the laminar boundary layer of an incompressible fluid. It is found that the assumption concerning the thickness of the boundary layer is not correct. Nevertheless, Wada's theory agrees fairly well with experiments.

J. A. Businger, USA

2203. Herzig, H. Z., and Hansen, A. G., On possible similarity solutions for three-dimensional incompressible laminar boundary layers III—Similarity with respect to stationary polar coordinates for small angle variation, *NACA TN* 3890, 36 pp., Jan. 1957.

Approximate solutions having similarity with respect to

stationary polar coordinate systems are obtained in the case of mainstream flows confined to regions of small angle variation over flat surfaces. The solutions, summarized in a table, include accelerating or decelerating flows and stagnation-point, spiral, or circular flows. An experimental comparison of limiting overturning at the wall shows good agreement for the first 10° of turning of circular mainstream flow.

From authors' summary by D. W. Dunn, Canada

2204. Moore, F. K., and Ostrach, S., Average properties of compressible laminar boundary layer on flat plate with unsteady flight velocity, *NACA TN* 3886, 35 pp., Dec. 1956.

The unsteady laminar boundary layer on a flat plate in compressible flow has been analyzed for the case of time-dependent flight velocity with a view to describing the time-average characteristics of such a boundary layer. Flight velocity is assumed to vary slowly enough so that the resulting boundary-layer flow is nearly, but not quite, quasi-steady. The wall temperature has been assumed constant both along the plate and in time.

To the second order in reduced frequency, each average quantity has two groups of terms: a time average of quasi-steady terms and terms related to the reduced frequency of the plate velocity fluctuations. The quasi-steady terms differ from the values for steady flow at the corresponding average velocity. These differences are reinforced by the frequency-dependent averages for adiabatic wall temperature and heat-transfer rate. In the case of skin-friction, the effects oppose one another. In the special case of harmonic velocity variation, authors conclude that oscillating the wall to increase the heat-transfer rate is not advantageous if the power to oscillate is accounted for, unless the Prandtl number is in a certain range.

Y. H. Kuo, China

2205. Crabtree, L. F., and Woollett, E. R., A new method for the solution of a differential equation with two-point boundary conditions applied to the compressible boundary layer on a yawed infinite wing, *J. roy. aero. Soc.* **60,** 552, 808–809 (Technical Notes), Dec. 1956.

For a nonhomogeneous linear differential equation with coefficients and the right-hand term given in tabulated form as functions of independent variable, and with the boundary conditions specified at two points, author proposes to obtain a solution by expressing it in polynomial form using Lagrange interpolation formula, and then solving the resulting system of equations by matrix methods.

Reviewer believes that, as far as the boundary-layer differential equation is concerned, this is but one of many approximate methods that can be used. For high accuracy, the work required by authors' method will be prohibitive; while with the present accuracy indicated by the author, the results usually can hardly be depended upon for further use to enter into higher approximations. In general, for a two-point boundary-value problem of boundary-layer-flow type, there seems to be no substitute for a careful setup of the numerical integration procedure. On the other hand, the present method might have its merit in handling two-point boundary-value problems of higher-order differential equations.

H. S. Tan, USA

2206. Cunsolo, D., On the compressible boundary layer on bodies of revolution (in Italian), *Aerotecnica* **36,** 3, 160–176, June 1956.

Critical review of 13 papers on laminar compressible boundary layer aims to expand the relatively simple integral method by Libby, Morduchow and Bloom [*NACA TN* 2655] to cases with axial symmetry. The results of the integral method are compared with the exact method by Chapman and Rubesin. It is found that it is sufficient to represent the velocity distribution by a sixth-degree polynomial with one parameter, if boundary-layer stability is being investigated. With the integral method, the boundary-layer thickness and the local skin-friction coefficient are calculated for a body of revolution determined by a second-degree equation of the meridian line.

G. W. Braun, USA

2207. Monaghan, R. J., On the behaviour of boundary layers at supersonic speeds, Proceedings of the Fifth International Aeronautical Conference, Los Angeles, June 20–23, 1955, 277–315; New York, Inst. of the Aeronautical Sciences, Inc.

Paper considers the implications, as regards skin friction and heat transfer, of recent work on supersonic boundary layers. Only the case of two-dimensional flow over a flat plate is considered. The empirical concept of "intermediate enthalpy" for laminar boundary layers is discussed. The self-induced pressure gradient due to displacement-thickness growth is calculated, and results are displayed. The corresponding effects on skin friction and heat transfer are determined; they are appreciable for Mach numbers greater than 5. For the turbulent boundary layer a mean enthalpy is proposed. Again, the induced pressure gradient is discussed.

Finally, the various results and proposals of the paper are applied to the case of flight at Mach numbers up to 10. Here the probable effects of transition and transition-delay are discussed, as regards both drag and aerodynamic heating. The favorable effect of radiation from the surface is pointed out and high-emissivity surfaces are proposed.

Although not intended as a survey, the paper includes considerable wind-tunnel data on flat-plate boundary-layer flow, as well as a list of 33 references.

W. R. Sears, USA

2208. Seban, R. A., Heat transfer to laminar boundary layers with variable free stream velocity, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–125, 10 pp. + 6 figs.

This is a companion work to that previously reported for the turbulent case by Seban and Doughty [AMR **9,** Rev. 1982]. By varying the passage width as a function of length in a wind tunnel, the boundary layer formed along a flat plate was subjected to a strong acceleration and then a moderate deceleration of the free-stream flow. Flow was subsonic with maximum flow velocities ranging from 260 to 900 fps. Local heat-transfer coefficients were measured for the condition of uniform heat flux at the plate surface. An approximate method for predicting heat-transfer coefficients is proposed, and calculated results based on constant properties are in satisfactory agreement with experimental information.

R. Siegel, USA

2209. Reshotko, E., and Tucker, M., Effect of a discontinuity on turbulent boundary-layer-thickness parameters with application to shock-induced separation, *NACA TN* 3454, 21 pp., May 1955.

The problem of shock-induced turbulent boundary-layer separation was analyzed by an approximate method. This method is based on a moment-of-momentum equation and calculates the change of boundary-layer-thickness parameters and form factor caused by a discontinuity where effects of friction can be neglected. The form of the result suggests that the Mach number ratio across the shock is a characteristic parameter for defining shock-induced separation. The method is also used to estimate the effects of mass transfer on the boundary-layer-thickness parameters for zero pressure gradient.

From authors' summary

2210. Reid, W. H., On the transfer of energy in Burgers' model of turbulence, *Appl. sci. Res. (A)* **6,** 2/3, 85–91, 1956.

Author examines the problem of energy transfer in J. M. Burgers' one-dimensional model of turbulence (the equation of motion being $U_t + UU_x = \nu U_{xx}$). The derivations are considerably simpler in this model compared to the three-dimensional isotropic case, while the essential nonlinearity of the general problem is preserved. Substituting the Fourier transforms of the double and

triple velocity product mean values in Burgers' model leads to definite equations for the time rate of change of the energy spectrum, if the assumption is made that the fourth-order mean values are related to those of second order, as they would be for a normal probability distribution. The transfer terms in the spectrum equation (which is of the same form as for isotropic turbulence) are considerably simpler in the one-dimensional model.

Two initial value problems are worked out: one corresponding to an exponential correlation function and the other to a micro-canonical or "block" spectrum. Due to the absence of a pressure term it is found that Burgers' equation does not lead to an algebraic behavior of the correlation functions for large separations. The second example reveals energy transfer to smaller as well as higher wave numbers. It is suggested, therefore, that the conventional cascade picture of energy flow unidirectionally from larger to smaller eddies may be inexact.

L. M. Grossman, USA

2211. Corrsin, S., and Lumley, J., On the equation of motion for a particle in turbulent fluid, *Appl. sci. Res.* (*A*) **6**, 2/3, 114–116, 1956.

Authors consider the unsteady Stokes' motion of a solid spherical particle in a turbulent fluid. They point out that in the generalized equation of Tchen [Tchen, C. M., "Mean value and correlation problems connected with the motion of small particles suspended in a turbulent fluid." Dissertation, Delft 1947, Martinus Nijhoff, the Hague] a number of terms appear to have been unjustifiably neglected. A more rigorous, but considerably more complicated, general expression is offered.

S. K. Friedlander, USA

2212. Makkaveyev, V. M., Turbulent mixing and the dynamics of channel flows (in Russian), Extracted from "Problems of channel flow", Leningrad, Gidrometeoizdat, 52–63, 1953; Rev. no. 1546, *Ref. Zh. Mekh.* 1956.

Report contains a brief survey of the work of the author and his associates on the theory of turbulent motion in a channel flow, as well as the theory of motion of suspended particles in a turbulent flow. G. I. Barenblatt, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2213. Glazova, E. F., and Laikhtman, D. L., The elementary theory of the wetted evaporator and its application in the investigation of turbulence (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 3, 278–281, 1955; Rev. no. 1547, *Ref. Zh. Mekh.* 1956.

The construction and principle of action are described of a continuously wetted evaporator surface, as suggested in 1951 by E. F. Glazova.

Formulas are given for determining the temperature of the evaporating surface, rate of evaporation, etc. The calculated results are compared with experimental observations.

Courtesy of Referativnyi Zhurnal Sh. A. Musaelyan, USSR
Translation, courtesy Ministry of Supply, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 2190, 2195, 2197, 2293)

2214. Woods, L. C. Generalized aerofoil theory, *Proc. roy. Soc. Lond.* (*A*) **238,** 1214, 358–388, Jan. 1957.

A general theory for inviscid subsonic flow of a Karman-Tsien tangent gas is developed so as to be applicable to flow over porous surfaces, separation cavities, or separation bubbles (that is, over free or mixed as well as fixed boundaries). It is assumed that the mass flow into the porous wall is small so that it may be linearly related to the pressure difference across the wall.

Generalized forms of the Blasius' formulas for both lift and moment are obtained for the tangent gas, and applied to the porous airfoil. There is also a discussion of the leading-edge stall and the resulting cavitation bubble. E. V. Laitone, USA

2215. Woods, L. C., On the theory of source-flow from aerofoils, *Quart. J. Mech. appl. Math.* **9**, 4, 441–456, Dec. 1956.

An exact theoretical treatment is developed for the influence of sources of fluid on and within two-dimensional airfoils in incompressible flow. In the case of a source placed within an airfoil, the fluid is ejected through a duct, the shape of which is taken into account in the theory. Formulas for the thrust, lift, and moment are derived from Blasius' theorem. These assume particularly simple form when attention is confined to thin airfoils. The case of the "directed" source receives attention, and the influence of the angle of ejection is determined.

From author's summary by J. R. Spreiter, USA

2216. Lachmann, G. V., Induced circulation (in German), *Z. Flugwiss.* **4**, 5/6, 173–178, May/June 1956.

Author considers theoretically the circulation induced about a Joukowsky airfoil by a vortex filament situated near its trailing edge carrying a circulation of high intensity. Filament simulates small chord airfoil whose circulation is thought of as augmented by blowing-out or a cylinder with porous surface through which air may be sucked away. Calculations are carried out for symmetric Joukowsky profile of 10% thickness with a porous cylinder of diameter one-half profile thickness at 15 locations near profile trailing edge. Substantial lift increments are obtained. Possible applications envisaged are: (a) replacement of conventional flaps, (b) re-inforcing the effect of flaps, (c) replacing conventional control surfaces of substantial chord hinged to fins, tailplanes or wings which on large fast aircraft produce excessively large hinge moments, so that power operation of the controls becomes necessary. W. H. Pell, USA

2217. Kikuchi, H., Theory for characteristics of aerofoils of arbitrary form arranged in cascade, *Rep. Inst. high Speed Mech., Tohoku Univ.* (*B*) no. 6, 103–114, 1956.

By means of conformal mapping techniques the potential flow field about cascaded airfoils of arbitrary form are obtained. An approximation valid for thin foils which greatly simplifies the problem is developed. Lift coefficient and surface velocity distributions are computed. Reviewer believes the technique to be a powerful tool for analysis of this and similar problems.

J. P. Craven, USA

2218. Spence, D. A., The lift coefficient of a thin, jet-flapped wing, *Proc. roy. Soc. Lond.* (*A*) **238,** 1212, 46–68, Dec. 1956.

A solution is given for the inviscid, incompressible flow past a thin, two-dimensional wing at a small incidence, at the trailing edge of which a thin jet emerges at a small deflection angle measured from the chord line. The flow inside the jet is assumed to be irrotational, and bounded by vortex sheets across which it is prevented from mixing with the main stream.

An integral equation is obtained for the slope of the jet, by aligning the trailing vortex sheet in the undisturbed-stream direction. The solution for a flat plate airfoil is expressed as the sum of a Fourier series, together with a function possessing the correct (i.e. logarithmic) form of singular behavior at the trailing edge. Simple expressions are obtained for lift, pressure distribution, and pitching moment. In particular, a simple expression is given relating the lift coefficient to the deflection angle of the jet, angle of attack of the plate, and the momentum-flux coefficient.

Close agreement with the theory is found in tests made on an 8:1 uncambered elliptic cylinder with a narrow deflected jet exit

close to its trailing edge for jet deflection angles of 30 and 60 degrees. The measured lift coefficients lie within 5% of the corresponding calculated curves (an allowance of 12½% having been made for thickness) and the observed centers of lift lie within 2% of the chord of those calculated for a thin airfoil, over the whole range of momentum-flux coefficient. For the 30-degree angle of deflection the agreement between theory and experiment is close to a lift coefficient as large as 7.6.

From author's summary by N. Tetervin, USA

2219. Malavard, L., and Jousserandot, P., Theoretical and experimental studies of the control of circulation by blowing applied to airplane wings (in French), *ONERA NT* 37, 40 pp. + 27 figs., 1956.

2220. Love, Edna M., and Williams, J., Additional data on surface slopes of the RAE 100–104 aerofoil sections, *Aero. Res. Counc. Lond. curr. Pap.* 252, 10 pp., 1956.

To supplement earlier data, the surface slopes of the RAE 100, 101, and 103 sections are tabulated, and for the RAE 102 and 104 sections additional values are quoted closer to the leading edge than before. An elementary but flexible method of specifying the minimum number of tangent planes needed for airfoil manufacture is also given.

From authors' summary

2221. Young, A. D., Note on the wave drags of untapered wings with streamwise tips at zero lift, *Aero. Quart.* **7,** 3, 240–246, Aug. 1956.

The linearized theory of supersonic flow has demonstrated in a number of cases the equivalence between the wave drags of yawed or swept wings of constant symmetrical section at zero angle of attack and the corresponding values in two-dimensional flow. Author has obtained a general equivalence theorem and has proved it very simply. It is shown from the theorem that the drag coefficient of the swept-wing combination with supersonic leading edge is the same as that of the infinite sheared wing, provided that the Mach cones from the leading edge of the center line do not intersect either of the wing tips.

Reviewer appreciates this general theorem and its interesting deductions.

T. Okamoto, Japan

2222. Gersten, K., Investigation of the downwash behind delta wings in incompressible flow (in German), Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt, 151–161; Braunschweig, Friedr. Vieweg & Sohn, 1955.

Theoretical and experimental techniques are applied to the downwash problem behind a delta wing. The lifting surface theory of Truckenbrodt [title source, 40–65, 1953] is used; an asymptotic approximation is given which simplifies this theory greatly for regions not close to the wing. Experiments are described using the tuft-grid technique. The wings tested had the same area, aspect ratios of 2, 3, and 5, NACA 0012 airfoil, artificial roughness at the 15% chord line. The Reynolds number of the tests varied from (2 to 5) × 10^5 referred to the mean chord. The accuracy of the tuft-grid data is not stated numerically. Comparison of experiment and theory at an angle of attack of 23.2° is given.

The following is concluded: The spanwise distribution of downwash is, for practical purposes, constant over a central strip about half a span wide. Within this strip and over a downstream distance of about two mean chords, the downwash is not influenced by the rolling-up of the vortex sheet.

H. P. Liepman,,USA

2223. Williams, W. C., Drake, H. M., and Fischel, J., Comparison of flight and wind-tunnel measurements of high-speed-airplane stability and control charateristics, *NACA TN* 3859, 16 pp., Aug. 1956.

Comparisons of wind-tunnel and flight-measured values of stability and control characteristics are of considerable interest to the designer, since the wind-tunnel method of testing is one of the prime sources upon which estimates of the characteristics of a new configuration are based. In this paper comparisons are made of some of the more important stability and control characteristics of three swept-wing airplanes as measured in flight and in wind tunnels. Wind-tunnel data from high-speed closed-throat tunnels, a slotted-throat transonic tunnel, and a supersonic tunnel are used.

The comparisons show that, generally speaking, the wind tunnels predict all trends of characteristics reasonably well. There are, however, differences in exact values of parameters, which could be attributed somewhat to differences in the model caused by the method of support. The small size of the models may have some effect on measurements of flap effectiveness. When nonlinearities in derivatives occur during wind-tunnel tests, additional data should be obtained in the region of the nonlinearities in order to predict more accurately the flight characteristics. Also, nonlinearities in static derivatives must be analyzed on the basis of dynamic motions of the airplane. Aeroelastic corrections must be made to the wind-tunnel data for models of airplanes which have thin surfaces and are to be flown at high dynamic pressures. Inlet effects can exert an influence on the characteristics, depending upon air requirements of the engine and location of the inlets.

From authors' summary

2224. Loewy, R. G., A two-dimensional approximation to the unsteady aerodynamics of rotary wings, *J. aero. Sci.* **24,** 2, 81–92, 144, Feb. 1957.

Paper gives a simplified treatment of the unsteady flow field of a rotor with low inflow, taking into account the influence of vorticity shed from the blades and blown below the rotor disk. The physical system is simplified by assuming that only the vorticity in the neighborhood of the blade is of importance. It is also assumed that the flow problem at a given blade radius is two-dimensional, the rows of shed vorticity from other blades or from the given blade at a previous time being situated in parallel rows beneath the given blade. This treatment is intended only as a first step in the development of a more satisfactory airfoil theory for rotors. Components of forward speed in the plane of the rotor have been neglected.

With the above simplifications, formulas are derived for the downwash and pressure distributions. The results are very similar to Theodorsen's [*NACA tech. Rep.* 496], the lift deficiency function being modified by an extra term due to the vorticity shed by preceding blades and/or in previous revolutions. The effect of inflow ratio, number of blades, phasing of blades, and the ratio of oscillatory to rotational frequency are investigated and charts are given in terms of the reduced frequency parameter. The results approach those for fixed wings as the product of reduced frequency and inflow ratio increases.

It is shown that the lift and moment on a multi-bladed rotor can be obtained from results on an equivalent single-bladed rotor.

Curves of aerodynamic damping coefficient for flapping and pitching motions are given showing that these effects (1) reduce the flap damping significantly when the oscillatory frequency is a multiple of the rotational frequency, and (2) make single-degree-of-freedom flutter possible for certain positions of the pitch axis.

As the author suggests, it would be very worthwhile to extend this work to include (a) three-dimensional effects and (b) influence of forward speed.

A. W. Babister, Scotland

2225. Shulman, Y., Stability of a flexible helicopter rotor blade in forward flight, *J. aero. Sci.* **23,** 7, 663–670, 693, July 1956.

The stability of the transient motion in the flapping plane is solved for two degrees of freedom—rigid flapping and elastic bending. The linearized governing equations are solved first by a

two-term modified Fourier series approximation, then also by numerical integration, using the MIT "whirlwind" high-speed computer. It is shown that the results obtained by inclusion of the elastic degree of freedom agree with experimental results to a much greater extent than was achieved by analyses neglecting blade flexibility. Y. C. Fung, USA

2226. Ribner, H. S., Spectral theory of buffeting and gust response: unification and extension, *J. aero. Sci.* **23,** 12, 1075–1077, Dec. 1956.

The statistical approach to the dynamic response of aircraft in turbulent air, pioneered by Liepmann, is formally generalized by treating the turbulence as a spectrum of plane sinusoidal waves of shearing motion of all orientations and wave lengths. The method requires the prior determination of a generalized transfer function relating aerodynamic loading and downwash as well as a "spectral density" function describing the mean square upwash distribution over the spectrum of wave lengths; the paper does not attempt to deal with the determination of these functions. The simplifications involved in considering the aircraft as a lifting surface, lifting line, or lifting point, are briefly indicated.

A. D. Young, England

2227. Rodden, W. P., An aeroelastic parameter for estimation of the effects of flexibility on the lateral stability and control of aircraft, *J. aero. Sci.* **23,** 7, 660–662, July 1956.

2228. Guyett, P. R., and Poulter, D. E. G., Measurements of pitching moment derivatives for a series of rectangular wings at low wind speeds, *Aero. Res. Counc. Lond. curr. Pap.* 249, 21 pp. + 18 figs., 1956.

The direct aerodynamic moments for pitching oscillations have been measured on a series of rectangular wings having aspect ratios between 2 and 8 for axis positions at the wing leading edges and trailing edges. Two of the wings were also tested with single end plates which were aerodynamically effective in doubling the wing geometric aspect ratio. The measurements were made at low speeds in an open jet wind tunnel and covered the range of frequency parameter (based on wing chord) 0.13 to 0.39. The results are in general agreement with theoretical results due to Lawrence and Gerber.

Similar tests were also made on a wing fitted with two end plates in an attempt to obtain results for two-dimensional flow. The results do not agree with other experimental results and two-dimensional theoretical values and indicate that wind-tunnel interference is important for this test configuration.

From authors' summary

2229. Muller, W., Static stability of an airplane in diving and gliding (in German), *Öst. Ing.-Arch.* **10,** 2/3, 225–232, 1956.

Author considers equations of longitudinal motion for small disturbances from steady symmetric flight when incidence variations are negligible—an assumption applicable to very stable airplanes. The perturbations in forward speed and angle of descent apply to the long period motion and are shown to satisfy second-order differential equations with constant coefficients. Both damping and stiffness are positive for gliding and diving. This solution is an extension of Lanchester's phugoid analysis to include the effects of drag, of flight-path inclination to the horizontal, and of speed variations in lift and drag.

When the inclination γ_0 of the steady flight below the horizontal is less than 70.5° (i.e., $\cos \gamma_0 > 1/3$), the motion is defined as gliding, and the perturbations satisfy equations of damped harmonic motion. After a small disturbance, the flight path is at first oscillatory and damped but is ultimately parallel to the initial steady flight.

Diving flight is defined to occur when $70.5° < \gamma_0 < 90°$ (i.e. $1/3 > \cos \gamma_0 > 0$) and the motion is overdamped. After a small disturbance, the flight path now tends asymptotically to a straight line parallel to, but at a small distance from, that of the steady flight.

The special cases $\cos \gamma_0 = 1/3$ and 0 are discussed briefly. Paper also contains a section on elevator angle and hinge moment. Results are interesting but, necessarily, of limited application.

S. Kirkby, England

2230. Sacks, A. H., Aerodynamic interference of slender wing-tail combinations, *NACA TN* 3725, 81 pp., Jan. 1957.

Mathematical expressions are derived for the interference forces and moments acting on the tails of slender plane and cruciform wing-tail combinations of general planform in steady straight flight at combined angles of attack and side-slip. The derivations are made within the limitations of slender-body theory under the assumption that the vortex sheet leaves the wing as a flat sheet and becomes fully rolled up ahead of the tail. The derived expressions are used to calculate the steady lifts, side forces, pitching moments, and rolling moments of a number of wing-tail combinations. The effects of changes in tail height, tail length, ratio of tail span to wing span, tail incidence, and tail thickness are calculated. The resulting curves, and particularly their nonlinearities, are discussed at some length in connection with static stability.

From author's summary by T. H. Lin, USA

2231. Mitcham, G. L., Stevens, J. E., and Norris, H. P., Aerodynamic characteristics and flying qualities of a tailless triangular-wing airplane configuration as obtained from flights of rocket-propelled models at transonic and low supersonic speeds, *NACA TN* 3753, 57 pp., Nov. 1956.

Results of flight tests from three rocket-powered models are presented for the Mach number range between 0.75 and 1.28. Analysis of aerodynamic characteristics and stability derivatives showed that the variation of lift coefficient with angle of attack was linear within the range of angles tested and the lift-curve slope increased gradually between Mach numbers of 0.88 and 1.00.

The hinge-moment coefficients increased rapidly between Mach numbers 0.85 and 1.15 but decreased gradually above a Mach number of 1.20. Elevator effectiveness decreased approximately 40% through the transonic region.

Static and dynamic longitudinal stability existed throughout the test Mach number range, with the center of gravity located at 20 and 25% mean aerodynamic chord. The aerodynamic center showed a gradual rearward movement of about 15% mean aerodynamic chord in the transonic region.

An analysis of the flying qualities of a full-scale configuration based on an assumed triangular-wing airplane with a wing loading of 27.3 lbs/sq ft at sea level and at a 40,000-ft altitude has been made from the data obtained from the three tested models.

From authors' summary by E. Eujen, Germany

2232. Kirby, R. H., Exploratory investigation of the effectiveness of biplane wings with large-chord double slotted flaps in redirecting a propeller slipstream downward for vertical take-off, *NACA TN* 3800, 22 pp., Oct. 1956.

Results are presented of static-force tests made in the static-thrust facility of the Langley free-flight tunnel on biplane wings with large-chord double slotted flaps which turn the slipstream of a single counterrotating propeller downward for vertical take-off. The span of the wings was approximately equal to the theoretical diameter of the slipstream (70% of the propeller diameter). The investigation provided information on the effect of chord length, flap deflection, propeller position, end plates, fuselage, and ground proximity on the efficiency of the wing system in turning the propeller slipstream.

The investigation showed that it was possible to turn the propeller slipstream 90° so that the resultant-force vector of the wing-propeller combination was normal to the propeller shaft and was 80% of the magnitude of the propeller thrust. When the model

was near the ground, the slipstream was turned only about 75°, but the resultant force increased to about 88% of the thrust. The resultant force was reduced about 10% when a fuselage was added to the wing system. Sealing the slots on the wings had no effect on the turning effectiveness when the model was well above the ground, but the resultant force was reduced if the slots were sealed when the model was near the ground. End plates were essential for obtaining high turning angles and efficiency.

From author's summary

2233. Castagno, A., Side-wind influence on the boundary layer on a cylindrical body in a high-speed compressible stream (yawed or swept wing) (in Italian), *Aerotecnica* **36,** 3, 152–159, June 1956.

2234. Burns, Anne, Fatigue loadings in flight: loads in the tailplane and fin of a Varsity, *Aero. Res. Counc. Lond. curr. Pap.* 256. 14 pp. + 6 figs., 1956.

Data are presented on the number of load cycles of various sizes occurring in the tailplane and fin of a Varsity in normal ground and flight conditions. The conditions include flight in turbulence, take-off, landing, taxiing, and ground running of the engines. The relative importance of the loads in the different conditions is illustrated by reference to the loads in a typical flight.

From author's summary

2235. Budiansky, B., and Mayers, J., Influence of aerodynamic heating on the effective torsional stiffness of thin wings, *J. aero. Sci.* **23,** 12, 1081–1093, Dec. 1956.

Analysis is made of the loss of torsional stiffness that may be incurred by thin wings subjected to axial stresses induced by aerodynamic heating. Theoretical results are presented for the effective torsional stiffness of solid wings of symmetrical double-wedge cross section accelerated to supersonic speeds. It is demonstrated that serious losses of torsional stiffness may occur in such wings; the influence of various parameters such as Mach number, acceleration, and thickness ratio is discussed. Mechanism considered is as follows: Leading and trailing edges, being thinner than mid-section, rise in temperature more rapidly during accelerated flight. Thermal stress puts edges of wings in compression. These stresses are relieved if wing twists.

F. R. N. Nabarro, South Africa

2236. Brooks, G. W., and Houbolt, J. C., Analytical determination of the natural coupled frequencies and mode shapes and the response to oscillating forcing functions of tandem helicopters, *NACA TN* 3849, 45 pp., Dec. 1956.

The analysis is limited to vertical vibrations. The kinetic energy and the potential energy are expressed in terms of generalized coordinates and chosen uncoupled modes of the fuselage, the rotor blades, and the engine. The energy equations are substituted in Lagrange's dynamical equations for free vibrations. By matrix manipulation the resulting vibration matrix is made symmetrical, and the coupled modes and frequencies are determined. The response to oscillating forcing functions is derived in terms of normal coordinates. Structural damping is included in the anaylsis by adding a small viscous damping term to each differential equation for a normal coordinate. Reviewer believes this procedure is only justified if the damping is very small and if, in resonance conditions, one natural mode gives a predominating contribution to the motion.

The results of calculations indicate that the natural frequencies of the symmetrical coupled modes vary appreciably with changes in the uncoupled frequency of the fuselage; however, the effect on the natural frequency of the antisymmetrical coupled modes is negligible. Further, the influence of reducing the number of generalized coordinates in the analysis and the influence of the rotor speed and the Southwell coefficient for the blade first elastic flapwise bending mode has been examined. Possible refinements of the method leading to a more complete analysis are mentioned. The results also emphasize that it is very unlikely that all natural frequencies of a helicopter could be obtained by observing the response to oscillating forces applied at any given point.

J. F. Besseling, Holland

2237. Scheubel, F. N., Shock forces during opening of parachutes and means for their reduction (in German), *Z. Flugwiss.* **4,** 5/6, 186–190, May/June 1956.

The physical reasons for the occurrence of shock forces, often very large, during the opening of a parachute are discussed, and possibilities of reducing the shock caused by opening of the parachute are deduced.

From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 2224, 2226, 2235, 2274)

2238. Woolston, D. S., Runyan, H. L., and Andrews, R. E., An investigation of effects of certain types of structural nonlinearities on wing and control surface flutter, *J. aero. Sci.* **24,** 1, 57–63, Jan. 1957.

Paper presents results of interesting theoretical and experimental investigation of effect of structural nonlinearities on two-dimensional low-speed flutter of two- and three-degree-of-freedom wing-aileron system. Structural nonlinearities are idealized to simulate play or flat spot, hysteresis, and cubic force displacement law. Analysis is carried out on analog computer. For case of wing bending-torsion flutter with flat spot in moment-twist law experiments were carried out in two-dimensional channel and compared with computer analysis.

Results indicate flutter behavior is entirely different from that expected on basis of the classical linear theory. For example, flutter speed is shown to depend on amplitude of initial disturbance and on load on system prior to disturbance. A more complete picture of flutter is obtained. Authors conclude that anomalous behavior of control surfaces with respect to flutter on presumably identical airplanes may be due to nonlinearities in control systems.

P. A. Libby, USA

2239. Molyneux, W. G., and Ruddlesden, F., Some flutter tests on swept-back wings using ground-launched rockets, *Aero. Res. Counc. Lond. Rep. Mem.* 2949, 16 pp., 1956.

Report gives the results of tests on flutter models of untapered wings with 20 deg, 40 deg, and 60 deg sweepback. Tests have been made up to a Mach number of 1.4.

A comparison is made between the measured flutter speeds and the speeds estimated using a flutter-speed formula. Modifications to the formula are proposed which include a compressibility correction of the form $(1.0 - 0.166M \cos \Lambda)$, $0 < M \cos \Lambda < 1.6$, where Λ is the angle of sweepback.

A comparison is also made between measured flutter speeds and those calculated using two-dimensional incompressible flow theory. This shows that the calculated speeds are lower than the measured speeds except in the transonic region, where they are in some cases slightly higher. The calculated flutter frequencies are on the average some 20% higher than the measured values.

From authors' summary

2240. Frazer, R. A., and Jones, W. P., Spring tab flutter, Part I. A theoretical investigation on wing-aileron-tab flutter, *Aero. Res. Counc. Lond. Rep. Mem.* 2952, 1–89, 1956.

Paper reports work done in 1942 when this problem was of great engineering importance. In the first and main part of the paper, theoretical calculations are presented on the two- and three-degrees-of-freedom flutter of a dynamical system consisting of port and starboard wing-aileron-tab combinations together with the

control column and interconnections. Critical speeds are found by a graphical method similar to one given earlier by Cicala. Strip theory for unsteady incompressible flow is used for the air forces. Special numerical calculations apply approximately to the airplane Spitfire, but the main purpose of the paper is not to predict the critical speed on any existing airplane but to provide design rules for spring tabs in order to avoid flutter. Those rules are found mainly from the two-degrees-of-freedom calculation, whereas those for three degrees of freedom are used as a check.

The main conclusions are that, in order to prevent flutter, the density ratio between the aileron and the tab should be high, and that mass-balancing of the tab is only effective when the balancing mass is placed sufficiently close to the tab hinge. If the mass is placed too far forward it can seriously lower the critical speed.

M. Landahl, Sweden

2241. Scruton, C., Williams, J., and Miles, C. J. W., Spring tab flutter. Part II. Experiments on binary aileron-tab flutter, *Aero. Res. Counc. Lond. Rep. Mem.* 2952, 90–95, 1956.

This part of the paper reports some experiments which confirm the conclusions reached in the theoretical part.

M. Landahl, Sweden

2242. Meller, A.-G., and Berton, A., Some measurements of the aerodynamic damping of aerofoils in cascade (in French), *ONERA* no. 53, 13–20, Sept./Oct. 1956.

Aerodynamic damping of a cascade of encastrée blades of airfoil section is determined experimentally in a specially constructed wind tunnel. The method employed is to deflect the free end of the central blade and to suddenly release it by burning through a wire. The resulting vibrations are recorded, using strain gages mounted near the fixed ends of the blades. The variation of the flexural internal damping coefficient with blade spacing, blade angle, and with wind incidence and velocity is determined. Qualitative results obtained were: (1) For the blades considered (aspect ratio $\simeq 9$), aerodynamic damping was large compared with structural damping; (2) the damping coefficient passes through a maximum and diminishes rapidly as wind speed increases; (3) the damping coefficient passes through a maximum as each of the four parameters is varied; (4) reduction in the blade spacing leads to a reduced critical speed for flutter; (5) the frequency decreased by 10 to 12% as speed increased.

Tests carried out on aerodynamic coupling between adjacent blades showed that: (1) Increasing wind incidence increased the coupling above a certain speed; (2) increasing the blade angle retarded the coupling; (3) increasing the speed increased coupling; and (4) increasing the spacing reduced coupling.

Results are applicable mainly to steam-turbine practice. It is intended to carry out further tests on flexural and torsional vibrations.

R. N. Cox, England

2243. Templeton, H., Models for aero-elastic investigations, *Aero. Res. Counc. Lond. curr. Pap.* 255, 12 pp. + 10 figs., 1956.

An account is given of several types of aeroelastic model used for flutter investigations. The various purposes for which they are used are outlined, and the scale relationships for prediction models are derived. Different types of model construction are described and their main applications are defined.

From author's summary

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2027, 2036, 2037, 2162, 2214, 2242, 2284, 2301, 2328, 2338, 2367, 2368)

2244. Jimbo, H., Investigation of the interaction of windage and leakage phenomena in a centrifugal compressor, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-47, 17 pp.

Earlier investigations of disk friction losses have been performed without consideration of the inward flow in the space between disk and casing wall, caused by leakage losses at the compressor wheel inlet [e.g., *Sulzer tech. Rev.* no. 1, 1937]. After theoretical deduction of the tangential velocity ratio and the pressure coefficient along the disk side, the windage loss coefficient and the leakage flow coefficient for constant flow rate and constant pressure difference, respectively, are calculated for various spacing factor $(S - s)/R_0$ width of clearance/radius of outer rim of shroud. In an apparatus consisting chiefly of a disk of one foot outer diam rotating at 6000 rpm, theoretical curves are verified.

Author states (1) The windage loss, the tangential velocity profile, and pressure distribution are independent of the clearance for constant flow rate. (2) The windage loss and the tangential pressure distribution depend on the rate of the inlet tangential velocity of the leakage flow.

The influence of the leakage flow appears from the fact that author has found constant windage loss coefficient where the Sulzer experiment gave an increase of about 10%. Paper would have been more interesting had the research also been carried out at a much higher disk Reynolds number, which generally is needed in compressor construction.

I. Jung, Sweden

2245. Andrews, S. J., and Ogden, H., The effect of lacing wire on axial compressor stage performance at low speeds, *Aero. Res. Counc. Lond. curr. Pap.* 225, 12 pp. + 9 figs., 1956.

Four stages of free vortex blades were tested at low speed in the 106 compressor to determine the effects of lacing wire upon stage efficiency and temperature rise.

With lacing wire of 0.14-in. diam in the rotor and stator, and with blades of height 2½ in., the loss in stage efficiency is about 12%, but if 0.14-in. diam tubular lacing is deformed within the blade pitch to a more streamlined section of 2½ : 1 fineness ratio, the drop in stage efficiency would be about 5%.

It is estimated that for the circular wire 30% of the increase in loss is due to the wire drag itself and 70% is due to interference by the wire in the normal blade flow.

From authors' summary

2246. Forshaw, J. R., Taylor, H., and Chaplin, R., Alternating pressures and blade stresses in the axial-flow compressor, *Aero. Res. Counc. Lond. Rep. Mem.* 2846, 29 pp., 1956.

The majority of blade failures in axial-flow compressors have occurred in the rotor blades of the lower pressure stages. These have been caused mainly by fatigue in the fundamental flexural mode of vibration in the presence of the steady centrifugal and gas bending stresses.

An investigation has been made into the origin of the forces exciting vibration in an axial-flow compressor, and their magnitude relative to the calculated gas bending loads. The blade stresses resulting from these forces were measured, and a value obtained for the energy input to a blade when vibrating in the predominant modes under running conditions.

The experimental data were obtained from pressure elements and strain gages fitted to the inlet guide vanes and first four stator-blade rows of an early compressor.

The oscillating pressure reached peak values when the forcing frequencies in a stage coincided with the blade natural frequencies of that stage or of adjacent stages, and was predominant for modes approximating to the fundamental flexural mode of vibration. This indicated that vibrations of any one stage 'modulated' the stream, the pressure waves extending upstream and downstream.

The magnitude of the alternating pressure was 40% and 5% of the stage pressure rise at 4000 and 8000 rpm, respectively. The ratio of the major harmonic components of the alternating stress to the

calculated gas bending stress was 2 : 1.3 : 0.6 at rotor speeds of 4000, 6000, and 8000 rpm.

Values of input energy and kinetic energy obtained for resonances approximating to the fundamental flexural mode showed that the damping present in a stator blade was high. Contributing factors to this high damping were the light root platform and loose fit of some blades.

The prominence of blade vibration resulting from modulation of the air stream by the vibration of blades in adjacent stages is attributed to the high damping present.

From authors' summary

2247. Moore, R. W., Jr., Skewed boundary-layer flow near the end walls of a compressor cascade, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-131, 11 pp. + 1 table + 14 figs.

Flow conditions existing near the hub of an axial compressor were produced in a cleverly designed stationary cascade. In such a compressor, the boundary layer developing on the stationary inner shroud of a row of stator blades is skewed when viewed by an observer who moves with the rotating blades. This means the velocity vector in the boundary layer has smaller angles toward the circumferential direction than the velocity vector outside the boundary layer. In the stationary cascade such a flow is produced in the following way. A shallow groove is machined into the cascade wall in front of the leading edges of the blades and an airjet is blown through this groove in the proper direction. It thus imparts to the mainflow boundary layer a sidewise motion. Resulting measurements of the velocity field in the flow through the blades show that the skewness of the boundary layer counteracts the effect of blade curvature on the three-dimensional boundary layer flow.

E. R. G. Eckert, USA

2248. Scholz, N., Calculation of the characteristic curve of an axial-compressor based on boundary-layer considerations (in German), Jahrbuch der Wissenschaftlichen Gesellschaft für Luffahrt, 205-213, Braunschweig, Friedr. Vieweg & Sohn, 1955.

Using the method of Scholz [AMR **8**, Rev. 185] and Schlichting [AMR **8**, Rev. 3482] for calculating the velocity distribution on the surface of a cascade blade and using the method of Truckenbrodt [AMR **6**, Rev. 1341] and Speidel [AMR **9**, Rev. 1142] for calculating boundary layers, author calculates the pressure rise and the efficiency of a stage of an axial compressor in function of the output. The energy losses due to secondary flow and to tip clearance leakage are estimated.

A. Betz, Germany

2249. Johnston, I. H., and Knight, L. R., Tests on a single-stage turbine comparing the performance of twisted with untwisted rotor blades, *Aero. Res. Counc. Lond. Rep. Mem.* 2927, 11 pp., 1956.

An experimental single-stage turbine designed for the testing of a variety of blade forms with cold air is described together with the instrumentation provided for test measurements.

Performance results obtained on this unit from two rotor blade designs are presented and it is shown that for the incidence range covered by the tests an untwisted constant-section blade of about 10% reaction possesses characteristics of pressure loss and deflection nearly identical to those of a conventional rotor blade twisted along its length to conform to the requirements of radial equilibrium, the mean diameter sections of the two blade designs being identical. It should be noted that the rotor blade section used in these tests provides a gas outlet angle and degree of reaction which, although lower than those employed in current aircraft engine practice, may well become typical for designs requiring a higher volumetric flow per unit turbine frontal area, *e.g.*, a high temperature cooled turbine.

From authors' summary

2250. Castles, W., Jr., and Durham, H. L., Jr., Distribution of normal component of induced velocity in lateral plane of a lifting rotor, *NACA TN* 3841, 26 pp., Dec. 1956.

The values of the normal component of induced velocity in the longitudinal plane of a lifting rotor were previously presented by one of the authors [AMR **6**, Rev. 3172 and AMR **9**, Rev. 1912]. Calculations were based on a wake vortex system consisting of a uniform, semi-infinite, elliptic cylinder and were in reasonable agreement, for the higher speed flight conditions, with experimentally determined values of the induced velocities and induced angles [AMR **9**, Rev. 3325].

The present report extends the above work to cover the distribution of the normal component of induced velocity in the lateral plane of a lifting rotor. Values are given in the form of graphs and tables computed by use of the Biot-Savart relation. Graphs and tables may be used to estimate the values for any given rotor or set of laterally disposed rotors.

L. Goland, USA

2251. Tamboli, R. B., An energy approach to climb performance estimation of a turbo-jet transport aircraft, *Aero. Quart.* **7**, 4, 315-336, Nov. 1956.

The climb performance of a turbo-jet transport aircraft is considered, using the concept of the energy height. The analytical formulas used in evaluating the time needed, distance covered, and fuel consumed during climb under various conditions are developed. It is concluded that the application of this energy approach method to the climb performance estimation of a turbojet transport aircraft will prove satisfactory from the points of view both of the accuracy of the results and of saving some of the considerable time needed for the climb calculation by the conventional method. A numerical example is given to illustrate the usefulness, applicability, and flexibility of this method.

From author's summary

2252. Halupka, K., The pre-exhaust of two-stroke diesel engines (in German), *Motortech. Z.* **18**, 1, 4-7, Jan. 1957.

The exhaust blowdown or pre-exhaust for two-stroke cycle engines is examined for efficient methods of scavenging. An approximate calculation is given to determine the pre-exhaust pressure wave in the outlet duct. Numerous excellent graphs are presented for the design of ducts using the appropriate pressure drops and gas velocity.

J. H. Davidson, USA

2253. Kondratieva, T. F., Determination of valve losses in piston compressors (in Russian), *Sboznik stat. Vses. n.-i. i konstrukt. in-ta khim. mashinostr.* no. 18, 88-102, 1954; Rev. no. 764, *Ref. Zh. Mekh.* 1956.

An approximation method is described for calculating the pressure and energy losses in the self-acting valves of piston compressors. It is demonstrated that the losses in the valve are directly proportional to the square of the product of the mean piston speed by its area, and inversely proportional to the square of the rated valve opening (square of the product of the volume of flow through the valve by the area of the valve opening(s)). Since results of calculation by this method were found to diverge substantially from experimental results, author introduces correction coefficients into the relevant equations. A nomogram is given for determining the flow coefficient of port and ring type valves, obtained by wind-tunnel tests of valve elements in a steady flow.

Yu. A. Lashkov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2254. Teichmann, O. E., Analysis and design of air motors, *Prod. Engng.* **28**, 2, 167-178, Feb. 1957.

A comprehensive study of flow through vane air motors accounting for pressure drops, torque losses, and expansion efficiencies and other variables. Performance equations are derived using special (and some approximate) parameters in nondimensional form.

Results are graphed for ease of application to new and existing designs, and for determination of the effects of changing various motor and air line parameters.

Reviewer notes that compressor power required shown in Fig. 1 was computed for 14.7 psi and about 100 F inlet air. The power for polytropic compression was computed for an exponent n of about 1.3, or less than K, when for actual compression processes n must be greater than K because of turbulence. Otherwise the analysis should be helpful in evaluating specific vane air motors, their applications and installations. A. S. Andes, USA

Flow and Flight Test Techniques

(See also 2201, 2223, 2243)

Papers presented at the Sixth Meeting of the Wind Tunnel and Model Testing Panel, Nov. 2-6, 1954. Paris, France, Advisory Group for Aeronautical Research and Development (AGARD Memo. 17/P7).

The papers presented at this meeting are, in general, considerably superior in quality to those reviewed for the previous (fifth) meeting. The general grouping of papers as to subject matter as well as actual content is well arranged. Some seventeen papers were presented, covering the four main groups of supersonic wind-tunnel techniques and testing; transonic wind-tunnel design, techniques and testing; hypersonic facilities and testing techniques; and vertical spin tunnels. A considerable amount of experimental data and experience, all too often lost in laboratory files, is included in these papers. Reviewer feels that this volume is a very worthwhile compilation; papers are reviewed in order.

2255. **Girerd, H., Calibration of test sections and accuracy of measurements in wind tunnels,** pp. 1-40.

Paper discusses working section calibration, working section and model design as affecting measurements. Interesting interferometric data are presented from various French tunnels and accuracy discussed. Interesting pressure distribution results, ONERA hot-wire techniques, and discussions of tolerances of both measuring gear and tunnels themselves are presented.

G. V. Bull, Canada

2256. **Morris, D., and Winter, K. G., Requirements for uniformity of flow in supersonic wind tunnels,** pp. 41-47.

Based on an assumed aircraft model, the effects of nonuniformity of working section flow on pressure-distribution measurements and on force and moment measurements are analyzed. Reviewer feels a rather high standard of Mach number uniformity (M to be less than 0.003 at $M = 1.4$ increasing to 0.01 at $M = 3$ throughout the working section) is demanded, with a more normal permissible angular deviation of 0.1°. Conclusion of authors is that standard of British model manufacture must be improved.

Paper is not too realistic, and the practicability of obtaining these tolerances in normal supersonic wind-tunnel operation is not considered.

G. V. Bull, Canada

2257. **Morris, D. E., Calibration of the flow in the working section of the 3 ft. × 3 ft. tunnel, National Aeronautical Establishment,** pp. 48-90.

Some experimental pressure and flow direction results are presented from a calibration of the working section of of the referenced supersonic wind tunnel using wooden nozzle blocks. The results are inferred as indicating satisfactory quality for model testing, but not quite satisfactory for research use.

G. V. Bull, Canada

2258. **Raney, D. J., Flow direction measurements in supersonic wind tunnels,** pp. 91-108.

Paper discusses general requirements for adequate flow direction measurements in supersonic wind tunnels, methods of accomplishing this with examples of design and calibration of yawmeters, and a presentation and discussion of results from some RAE tunnel tests. This is a very interesting paper on techniques.

G. V. Bull, Canada

2259. **Haines, A. B., Holder, D. W., and Pearcey, H. H., Scale effects at high subsonic and transonic speeds, and methods for fixing boundary-layer transition in model experiments,** pp. 109-166.

Authors review the role of the boundary layer in contributing to scale effects when tests are conducted well below free-flight Reynolds numbers. To minimize these effects, similarity of boundary-layer conditions between the scale and full-scale tests is attempted by fixing the boundary-layer transition point on the wind-tunnel model. Authors describe several methods of fixing the transition point and present experimental results over the subsonic-transonic Mach number range for both two- and three-dimensional cases. Authors note good agreement in the two-dimensional case, with odd discrepancies being accountable; for the three-dimensional case, the method becomes extremely complex and not completely satisfactory.

This is, in reviewer's opinion, an extremely worthwhile paper. G. V. Bull, Canada

2260. **Winter, K. G., Scott-Wilson, J. B., and Davies, F. V., Methods of determination and of fixing boundary-layer transition on wind tunnel models at supersonic speeds,** pp. 167-191.

Authors review methods used for observation of boundary-layer phenomena, and present experimental results from sublimation and oil film techniques. Pressure measurements in an induced turbulent boundary layer on a 10° cone are presented.

G. V. Bull, Canada

2261. **Poisson-Quinton, P., and Chevallier, J. P., Identification and starting of the transition** (in French), pp. 192-197.

Authors discuss briefly the transition problem and methods of identifying the transition point; experimental results from half-model tests are presented to illustrate the effect of transition on force and moment characteristics of a delta wing-body combination at transonic Mach numbers. G. V. Bull, Canada

2262. **Allen, H. J., Transonic wind tunnel development of the National Advisory Committee for Aeronautics,** pp. 198-217.

Author reviews development of transonic, slotted-wall tunnels in the NACA laboratories and presents some experimental results on stream uniformity and pressure distributions over a body of revolution.

G. V. Bull, Canada

2263. **Maeder, P. F., Some aspects of the behavior of perforated transonic wind tunnel walls,** pp. 218-246.

Author investigates theoretically the properties of

slotted walls and shows correlation with results obtained using a plenum chamber. G. V. Bull, Canada

2264. Goethert, B. H., Flow establishment and wall interference in transonic wind tunnels, pp. 247–292.

Author reviews transonic wind-tunnel development at WADC, particularly emphasizing problems associated with transonic testing and means of overcoming them. Considerable amount of experimental data is included on same configuration but different model sizes. Paper is a very worthwhile treatment of subject.

G. V. Bull, Canada

2265. Wilson, R. E., Heat transfer and skin friction investigations in the NOL hypersonic wind tunnel, pp. 293–310.

Paper covers method used and measurements made in the turbulent boundary layer on the hypersonic tunnel nozzle wall in the Mach number range 5.0 to 8.2.

G. V. Bull, Canada

2266. Nagamatsu, H. T., GALCIT hypersonic research, pp. 311–332.

Author describes GALCIT hypersonic wind-tunnel facility and describes, with results, investigations on condensation of gases in hypersonic nozzles, transition studies on an insulated flat plate, shock-wave boundary-layer interaction in the hypersonic range. Brief treatment of hypersonic shock tube is presented.

G. V. Bull, Canada

2267. Allen, H. J., Development of two hypersonic test facilities at NACA Ames Laboratory, pp. 333–372.

Author reviews development of a small hypersonic wind-tunnel facility and a combination wind-tunnel ballistics-range facility, both devices useful for high Mach number testing. Paper presents a good descriptive coverage of facilities but is obscure in some details; reviewer notes discussion and reference to absence of condensation-of-air-components studies carried out at Princeton which were subsequently shown to be in error by NOL work of Wagener and others.

G. V. Bull, Canada

2268. Dodge, J. A., Ultra-high temperature aerodynamic testing facilities, pp. 373–393.

Author reviews work in various U. S. laboratories to design a usable hypersonic impulse tunnel shock tube with divergent walls. G. V. Bull, Canada

2269. Martinot-Lagarde, A., and Gobeltz, J., Improvements of the study of spinning wind tunnel, pp. 394–398.

Authors review and classify types of spirals encountered in vertical tunnel testing and make comparisons between free-flight and tunnel cases.

G. V. Bull, Canada

2270. Neihouse, A. I., Design and operating techniques of vertical spin tunnels, pp. 399–406.

Author reviews the NACA vertical spin tunnel facility in a most interesting manner. Some illustrative experimental results are included.

G. V. Bull, Canada

2271. Clarke, A. E., and Maltby, R. L., Vertical spinning tunnel at the N. A. E. Bedford, pp. 407–440.

Authors describe the tunnel facility and discuss design features such as choice of size and type.

G. V. Bull, Canada

2272. Anscombe, A., and Illingworth, L. N., Wind-tunnel observations of boundary-layer transition on a wing at various angles of sweepback, *Aero. Res. Counc. Lond. Rep. Mem.* 2968, 9 pp., 1956.

Visual observations have been made of boundary-layer transition on a wind-tunnel model of constant chord at zero lift over a range of sweepback angles from zero to 50 deg. At each angle above 25 deg, a critical speed could be found within the speed range of the tunnel (400 ft/sec) at which striations appeared within the laminar boundary layer, while the transition line itself lay at 50% to 60% chord. As the speed was further increased, transition started to move forward, finally occurring close to the leading edge. The wind speed at which the striations appeared and the forward movement of transition started, decreased with increasing angle of sweepback. From authors' summary

2273. Holder, D. W., North, R. J., and Chinneck, A., Experiments with slotted and perforated walls in a two-dimensional high-speed tunnel, *Aero. Res. Counc. Lond. Rep. Mem.* 2955, 59 pp., 1956.

Preliminary tests have been made with a 7½-in. × 3-in. two-dimensional induced-flow tunnel fitted with slotted or with perforated walls, and with a closed tunnel and an open jet of the same size. The experiments include observations of the pressures in the empty tunnel, and of the pressure distribution and flow pattern round a 2-in. chord at angles of incidence of 0 deg and 2 deg. The reliability of the measurements on the airfoil at high subsonic speeds is estimated by comparison with measurements in the 20-in. × 8-in. tunnel on an airfoil of the same section and chord.

By suitable design the Mach number in the empty tunnel can be varied continuously between zero and about 1.2, and reasonably uniform distributions can be obtained at all Mach numbers within this range. When the airfoil is present, choking can be avoided, and it is found that in all cases the major interference effect at zero incidence arises from blockage. The slot-area ratio (about 0.04) needed to minimize blockage is smaller than originally expected, and walls with larger slot area give blockage effects similar to those observed in the open jet. This agrees with the predictions of calculations which were completed after the experiments had been made. Although the blockage could be made small at Mach numbers up to about 0.9, it tended to the value for an open jet at higher subsonic speeds.

When the model is at incidence, the lift coefficients in the slotted tunnels lie between those measured in the closed and open tunnels, but the lifts measured in the walls which give minimum blockage are in reasonable agreement with those obtained in the 20-in. × 8-in. tunnel where the blockage is thought to be negligible. With these walls it was, however, only just possible to reach supersonic speeds, so that it seems that in two dimensions the design requirements which must be satisfied to give minimum interference at subsonic speeds are incompatible with those giving uniform supersonic flows at the highest possible Mach numbers. It seems from recent American work that this is not the case in a tunnel designed for three-dimensional testing.

It is difficult to estimate the reliability of the present tunnels at transonic speeds because the flow round a two-dimensional airfoil is insensitive to changes of Mach number near unity, and because reliable transonic data are not available for comparison. Also, little information has been obtained on the interference in a slotted tunnel when running at supersonic speeds.

The tests were made in two dimensions because a tunnel suitable for three-dimensional work was not available, and it seems that the design of a satisfactory two-dimensional slotted tunnel is more difficult than the design of a three-dimensional one. The utility of transonic tests on two-dimensional airfoils is, however, doubtful, and the main object of the present work was to provide

information and experience which would be useful in the design of a three-dimensional slotted working-section when a suitable tunnel became available. From authors' summary

2274. Jordan, P. F., and Smith, F., A wind-tunnel technique for flutter investigations on swept wings with body freedoms, *Aero. Res. Counc. Lond. Rep. Mem.* 2893, 11 pp., 1955.

In the past it has been usual to ignore the body freedoms of aircraft in making wing-flutter investigations. This practice is no longer justified for modern designs with swept wings, and especially for tailless aircraft. In this report a technique is described which has been developed for wind-tunnel tests on wing-flutter models with the body freedoms. A half-span wing model is used, attached to a rigid body; longitudinal stability is insured, and the body-mass parameters are reduced to small values by an appropriate arrangement of supporting springs. The ease of parameter variations makes the wind-tunnel rig suitable for systematic investigations.

From authors' summary

2275. Fail, R., Owen, T. B., and Eyre, R. C. W., Preliminary low speed wind tunnel tests on flat plates and air brakes: flow, vibration and balance measurements, *Aero. Res. Counc. Lond. curr. Pap.* 251, 21 pp. + 22 figs., 1956.

Flow measurements have been made behind sharp-edged flat plates: (a) at 90° for various shapes, and (b) for a square plate over an incidence range. The results of (a) show a closed bubble about 3 plate sides long, with a constant pressure boundary up to the maximum diameter, followed by mixing. Measurements of velocity fluctuations were made for (b), showing that a regular shedding of turbulent eddies occurs for $\theta = 50°$ and over, but stops by 40°. Large random low-frequency longitudinal fluctuations are associated with the shedding.

Lift, drag, and pitching moment increments were measured on a square plate mounted on (a) a long cylinder and (b) near the end of several shapes of rear fuselage, to see how the moments on opening the brake could be modified. Velocity fluctuation measurements, at 70° only, show a much reduced longitudinal unsteadiness when the plate is in proximity to the fuselage. Comparative tests were made on a cascade brake and show that no shedding occurs. From authors' summary

Thermodynamics

(See also Revs. 2198, 2299, 2300, 2302, 2304, 2305, 2306, 2310, 2311, 2318, 2351, 2356)

2276. Roy, M., Fundamental aerothermodynamics and concepts of aerothermochemistry (in French), *ONERA Publ.* no. 84, 68 pp., 1956.

This is an interesting and concise exposition of the thermodynamics of compressible fluid flow. Heat transfer and chemically reactive systems in flow are also considered. Although no new concepts are introduced the context of the presentation represents a new and valuable contribution to the literature.

An important consequence of this monograph is a fuller appreciation for the power of thermodynamics in fields other than those in which energy is the prime consideration.

J. F. Lee, USA

2277. Kyame, J. J., Matrix representation of thermodynamic fundamentals, *Amer. J. Phys.* **25,** 2, 67–69, Feb. 1957.

The thermodynamic variables P,T,V,S, are used as elements in a one-column four-row matrix ξ and the potentials G,F,U,H in another ϕ. A square matrix θ made up of elements $V,-S,-P,T$ is defined. The relation $d\phi = \theta\, d\xi$ then gives four familiar thermodynamic relations. Some further matrix operations yield the partial differential relations, including the Maxwell relations. Author hopes that matrix representation can be extended to include systems of variable mass.

In reviewer's opinion, author should state whether the equation $d\phi = \theta\, d\xi$ is a consequence of thermodynamic principles or merely a mathematical device which results in familiar relations.

J. H. Keenan, USA

2278. Eckert, E. R. G., and Irvine, T. F., Jr., A new method to measure Prandtl number and thermal conductivity of fluids, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-32, 4 pp.

An experimental method is described by which the Prandtl number and indirectly the thermal conductivity of air is measured. This method is based on the fact that a well-established relation exists between the Prandtl number and the recovery factor for laminar boundary-layer flow. The test set-up used for these measurements consists of a small (0.4-in. diam) rotationally symmetrical nozzle which produces a field of uniform velocity. Recovery conditions are established on the surface of coaxially strung thermocouple wire. One junction reads the recovery temperature and the second junction, which is located in a region where the air velocity is low, measures the total temperature. Total and static pressure measurements are also made.

These measurements are sufficient to calculate a value of the recovery factor and thereby the Prandtl number. Since the values of viscosity and specific heat of air are fairly well established, the value of the thermal conductivity may be deduced. A careful analysis of the possible systematic errors indicated that under the conditions of the experiment the resulting error may have a value up to 0.7%. The experimentally determined values of Prandtl number deviate by about ± 0.5% from a mean line through the data. A comparison between the measured values of thermal conductivity and a curve given by the National Bureau of Standards indicates that the reliability of 4% ascribed to the thermal conductivity of air by the National Bureau of Standards may be re-evaluated to 1%.

J. Persh, USA

2279. Landis, F., On the use of thermodynamic concepts in fluid mechanics, Proc. fourth Midwestern Conf. fluid Mech., Purdue Univ., Sept. 1955, 131–142.

Author considers fluid motion which is in "thermodynamic equilibrium", that is absence of viscosity and thermal conductivity (which has other implications such as the absence of dissipative effects). Main results are: A steady flow originating in a finite reservoir, in which the fluid is at rest and in thermodynamic equilibrium in ordinary sense, is irrotational. Steady or unsteady flows will remain irrotational only if they are instantaneously isothermal, isentropic, or if the temperature is a unique function of entropy only. Some further remarks concern fluids in steady flow with viscosity and thermal conductivity.

J. Meixner, Germany

2280. Melvin, M. A., and Edwards, S., Jr., Group theory of vibrations of symmetric molecules, membranes, and plates, *J. acoust. Soc. Amer.* **28,** 2, 201–216, Mar. 1956.

This is an application of the group theoretical method of analysis of molecular and atomic systems to two-dimensional systems and thin systems having pyramidal symmetry. The plates, shells, and tents of all regular polygonal shapes are investigated for stationary and spinning cases. The tables for complete sets of irreducible representation and character of symmetry groups are given for all cases mentioned.

Further, occurrence numbers in each symmetry-permitted type are determined, adapting general group-theoretical method to the system of molecules subjected to external and internal constraints.

The analogy between molecules and membranes and plate vibrations can be described in three stages: The classification of

permitted types of normal vibrations are identical in both cases; the actual occurrence number of normal vibration of permitted types is not identical as it depends on matter distribution. The frequency of vibration occurring in plates depends on mass distribution and elastic bindings.

The work shows that the group theoretical method of vibration can be extended to bodies of various shapes (even in 3 dimensions) and contribute to deeper insight into the body vibration in general.

A. L. Nasvytis, USA

2281. Gilvarry, J. J., Properties of the shock transition at low temperature, *J. appl. Phys.* **27,** 12, 1467–1472, Dec. 1956.

Author points out that, as given by Bethe's equation, the change of entropy across a strong shock wave grows without limit, an unrealistic physical behavior, when the temperature ahead of the shock approaches absolute zero. Author then examines the shock transition properties of substances having equations of state wherein the pressure is given by the sum of a volume-dependent component and a temperature-dependent component. The corresponding entropy is taken to be the product of a volume-dependent function and an arbitrary power of the temperature. These substances then resemble mathematical constructions such as the Fermi-Dirac gas, the Thomas-Fermi atom, the Debye solid, and the Mie-Grüneisen solid as special cases.

Using the Hugoniot shock condition, the Bethe-Weyl inequalities, and the foregoing equation of state, author deduces new properties of shock transition at low initial temperature by an extension of Bethe's method. Author finds the temperature and entropy changes across the shock properly bounded for an initial state arbitrarily close to absolute zero and finite shock strength, in contrast to the singular behavior implied by Bethe's results.

Author states that these new results are applicable to problems such as calculation of pressures and temperatures arising in the explosive impact of meteorites at high velocity.

H. A. Stine, USA

2282. Schmidt, E.. New steam tables (in German), *Brennstoff-Warme-Kraft* **8,** 11, 519–520, Nov. 1956.

Steam tables prepared by (1) Wukalowitsch, USSR, 1951, (la) Wukalowitsch and Elsner, Germany, 1954, (2) Ministry of Electric Power, USSR, 1952, (3) K. Quak, Germany, 1955, (4) Society of Mechanical Engineers, Japan, 1955, (5) E. Schmidt, VDI, Germany, 1956, (6) O. H. Faxen, Sweden, 1953, (7) L. Z. Dzung and W. Rohrback (Brown-Boveri), Germany, 1955, are reviewed. Comments on units employed in the several tables are presented. Good agreement between the VDI (5) and Wukalowitsch (1) tables was found. Quak's (3) values are an abstract of the VDI (5) and Wukalowitsch (1) tables. The Japanese (4) obtained their data from extrapolation of the equation of state of Tanishita. The VDI tables (5) were based on the equation of state of Koch and U. S. spectroscopic data for heat capacities. The VDI enthalpies are in good agreement with USSR tabulation (2). Faxen's tabulation (6) was based on the equation of state of Juza and involved deviations of 0.3% from the VDI and USSR data. Brown-Boveri tables (7) were based upon the work of Wukalowitsch (1) and do not include the superheated region. Because of good agreement among existing tables, one international steam table is recommended.

B. H. Sage, USA

2283. Kirillin, V. A., and Zubarev, V. N., Experimental investigation of the specific volume of water and water vapor at high pressures (in Russian), *Teploenergetika* **2,** 11, 19–23, Nov. 1955.

Authors describe method and apparatus used in carrying out a series of experiments to determine the specific volume of water and water vapor at pressures up to 918 atm, (13,230 lbs.) and 500C.

A table of experimentally obtained values of specific volumes supplements the description.

A formula is also given for calculating the enthalpy of water and water vapor, and also a second table with enthalpy values calculated from the suggested formula, for pressures ranging from 500 to 900 atm.

From authors' summary by W. Green, USA

2284. Ramsey, R. P., A new concept in engine gas-generator-turbine plant, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-204, 14 pp.

Author's scheme uses a four-stroke cycle reciprocating engine in which combustion products are not allowed to escape from cylinder at bottom dead center. They are recompressed to a pressure several times scavenging pressure, then escape through main exhaust valve to high-pressure section of turbine. Near top dead center blow-down valve opens, purging clearance gas from cylinder to low-pressure section of turbine.

Author claims suggested scheme would permit lower firing pressure, smaller scavenging blower, and reduced blow-down loss. Paper includes thermodynamic equations for cycle calculation, design charts, and numerical examples.

Reviewer believes suggested scheme has no thermodynamic advantage. Any mechanical advantage would be realized only at the expense of other mechanical complexities (triple valve, triple manifold). Paper contains several typographical errors. In equation (6) p_s should read p_3. In last paragraph on page 7, (p_3/p_1) should be 36 instead of 3.58.

T. C. Tsu, USA

2285. Dzung, L. S., The influence of combustion on the thermal efficiency of simple gas-turbine cycles, *Brown Boveri Rev.* **43,** 3/4, 63–78, Mar./Apr. 1956.

The heating by combustion of the working medium in the circuit of a gas-turbine cycle influences the thermal efficiency in two ways: first, the "heat consumption," i.e. the denominator employed in the expression for the efficiency, can be only somewhat arbitrarily defined because there is no heat flow from outside in the proper sense. Secondly, the properites of the working medium are different before and after combustion. Only the second influence has been considered in the literature published so far, and the terms "change of mole numbers" and "volume contraction" have been employed. The present article deals with the entire problem of combustion, internal and external to the medium circuit.

From author's summary by J. A. Landoni, Argentina

2286. Tanner, C. B., and Suomi, V. E., Lithium chloride Dewcel properties and use for dewpoint and vapor-pressure gradient measurements, *Trans. Amer. geophys. Un.* **37,** 4, 413–420, Aug. 1956.

Authors review the principle and operating characteristics of the Dewcel and describe the gradient in water-vapor-pressure above a crop, using two of these instruments for measuring. Samples drawn continuously from two elevations above the crop are sent alternately to each of the two Dewcel chambers, so that absolute differences between readings of the instruments are cancelled. With Dewcels properly ventilated, operated at equal air temperature, and with this nulling technique, authors conclude small vapor-pressure differences can be measured with errors less than 2 to 3%. Time constant of about 10 minutes makes the measurements slow.

W. P. Jensen, USA

Heat and Mass Transfer

(See also Revs. 2026, 2055, 2056, 2156, 2187, 2208, 2210, 2213, 2235, 2276, 2278, 2286, 2351, 2356)

Book—2287. Warburton-Brown, D., Induction heating practice, New York, Philosophical Library, Inc., 1956, 192 pp. $10.00.

This handbook on high-frequency induction heating, written primarily for those concerned with production, emphasizes the

practical aspects. Theory is minimized and presented in a simple, easy-to-understand manner. Book is fairly well written, amply illustrated, and provided with enough practical application to clearly illustrate the techniques. In addition, the publishers have done a fine job in printing.

Book is divided into nine chapters covering the design of work coils, inductors, locating jigs, and handling fixtures; the use of induction methods for soldering, brazing, hardening, gear hardening, annealing, tempering, sintering carbide tool tips, and other miscellaneous applications; and component design.

This should be a very useful reference to anyone desiring to make practical use of induction heating.

R. J. Mindak, USA

2288. Geisel, H., Computation of the depth of heating in inductional hardening (in German), *Werkstattstech. Maschinenb.* 46, 10, 519–522, Oct. 1956.

2289. Nonweiler, T., Conduction of heat within a structure subjected to kinetic heating, *Aircr. Engng.* **28,** 333, 383–387, Nov. 1956.

2290. Elrod, H. G., Jr., New finite-difference technique for solution of the heat-conduction equation, especially near surfaces with convective heat transfer, ASME Ann. Meet., New York, N. Y. Nov. 1956. Pap. 56-A-112, 21 pp.

Numerical solutions are obtained for the linear flow of heat, the lines of flow being parallel to the axis of x, by a finite-difference method, which is useful even if the behavior of the temperature has a certain degree of nonuniformity (for example, near the surface of a casting during quenching).

The method is useful when the temperature distribution at $t = 0$ is polynomial in x. The method is illustrated by numerical examples for the semi-infinite and finite slab, and the numerical results are in good agreement with theoretical values.

G. Sestini, Italy

2291. Biot, M. A., New methods in heat flow analysis with application to flight structures, *Cornell aero. Lab. Rep.* SA-987-S-3, May 1956.

In this outstanding report, author presents new methods for the analysis of transient heat flow in complex structures by applying general variational principles. The same procedures were applied to thermodynamic systems in earlier papers by the author. Such factors as surface and boundary-layer heat transfer, nonlinear systems with temperature-dependent parameters, and radiation are included. The concepts of thermal potential, dissipation function, and generalized thermal force are introduced. The application of the method is illustrated by examples, which include the heating of a slab with constant parameters, extension to nonlinear systems with temperature-dependent parameters and surface radiation, and heating and cooling of a slab with temperature-dependent parameters. The concluding example illustrates the calculation of the temperature field in a supersonic wing structure as a function of time.

The results are in good agreement with those obtained by much more elaborate procedures. The simplicity of the calculations required in the solution is a distinct advantage of the method.

This report is highly recommended for those interested in this area.

G. A. Hawkins, USA

2292. Crowley, M. S., Initial thermal expansion characteristics of insulating refractory concretes, *Bull. Amer. ceram. Soc.* **35,** 12, 465–468, Dec. 1956.

Paper presents laboratory data obtained by measurements of the changes in length of 6 in. by 1 in. by 1 in. specimens, heated uniformly in a horizontal tube furnace at controlled rates up to 450 F per hour. Correlations are shown between the general shape of the curve and the composition of the concrete, and between the shape of the curve and heating rate. Examples are given on the use of this type of data in design of furnaces.

From author's summary

2293. Abel, G. C., Report of the second year's flying on the development of flight testing techniques for finding and measuring natural icing conditions, *Aero. Res. Counc. Lond. curr. Pap.* 222, 12 pp. + 6 tables + 9 figs., 1956.

The results of the second year's flying in search of natural icing conditions are given in this report. Icing conditions extending over 100 miles have been found in stratocumulus clouds over areas from East Anglia to the English Channel. Average liquid water contents were 0.4 – 0.5 gms/m³, but an exceptional value of 1.4 gms/m³ is reported. Photographs of ice crystals and liquid water droplets together have been obtained. This advance in sampling technique is being extended to try to measure liquid water content and total water content by timing the exposures. The R.A.E. thermal ice detectors have not yet reached their final form but have been improved considerably. The Smiths ice detector has been calibrated to give liquid water content and, together with the rotating disk, has continued to be very valuable. Meteorological Office forecasts of icing conditions have continued to be reliable.

From author's summary

2294. Tong, L. S., and London, A. L., Heat-transfer and flow-friction characteristics of woven-screen and crossed-rod matrices, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-124, 16 pp. + 1 table + 15 figs.

Authors state that woven-screen or crossed-rod types of matrixes may be of interest as fuel-element geometries for nuclear reactors. In an earlier paper [AMR **9,** Rev. 1976], Coppage reported characteristics of woven-screen matrixes for a Reynolds number range of about 5 to 1000. Present report extends N_R range to 100,000, using crossed-rod matrixes. Experimental screen and rod results are correlated by taking into account the effect of wire inclination due to weaving. Nondimensional friction and heat-transfer data are presented for $5 < N_R < 100{,}000$, and for matrix porosities from 0.6 to 0.83. Correlating equations representing these data are given.

Although the Prandtl number was not varied in these tests, a factor $(N_{PR})^{\frac{2}{3}}$ is included in the correlating equation for Stanton number. Reviewer believes this factor should be more like $(N_{PR})^{0.6}$, because flow is more closely related to stagnation-point flow than to flat-plate flow.

G. M. Low, USA

2295. Kreith, F., and Taylor, J. H., Jr., Heat transfer from a rotating disk in turbulent flow, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-146, 15 pp.

The heat transfer from a rotating disk at constant temperature to a stagnant fluid has been investigated analytically by means of the Reynolds analogy and by the von Karman integral method. For a fluid with a Prandtl number of unity the equations were found to be of the form for both methods, $St = \text{constant } Re^{-1/5}$. The numerical constants obtained by the two methods differ, however, by between 20 to 35%, depending upon the temperature profile used in the integral relations. Further experiments are needed to verify the analysis at fully turbulent Reynolds numbers.

From authors' summary by D. C. Hamilton, USA

2296. Finston, M., Free convection past a vertical plate, *ZAMP* **7,** 6, 527–529, Nov. 1956.

The basic equations governing the "quasi-incompressible" free-convection flow about a vertical plate with variable surface temperature are reduced to ordinary differential equations by means of a generalized similarity transformation. The resulting equations yield those for uniform surface temperature (which have been solved) as a special case.

Several typographical errors should be noted; viz., v, the trans-

verse velocity, appears in the reference velocity and length in eq. (6) instead of ν, the kinematic viscosity; the sentence containing eqs. (18) and (19) is incomplete. S. Ostrach, USA

2297. Hartnett, J. P., and Welsh, W. E., Experimental studies of free convection heat transfer in a vertical tube with uniform wall heat flux, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-113, 7 pp.

Most previous studies have used constant wall temperature as a boundary condition. Authors studied effect of changing boundary condition to uniform wall heat flux, using same physical situation.

Measurements were made with 2-in. vertical steel tube, 21 in. high, closed at bottom and filled with water using wall-heater coils as heat source. Range covered Grashof-Prandtl product from $10^{3.8}$ to $10^{7.4}$.

Results agree with previous work of several authors for constant-wall-temperature case and authors conclude that there is no significant difference between two conditions.

A. Sesonske, USA

2298. Brown, W. G., and Colborne, W. G., Fundamentals of chimney performance, *Canad. J. Technol.* **34,** 5, 354-365, Sept. 1956.

Tests on geometrically identical, thin-walled, nonradiating chimneys and considerations for other kinds of chimneys showed design data can be obtained from model tests. Methods are outlined for preparing design charts and using models to study wind effects. The performance of the thin-walled nonradiating chimney (or similar heat exchangers) is shown to depend on the same variables encountered in isothermal flow theory.

From authors' summary

2299. Hedge, J. C., Performance of the ARF vortex free air thermometer at subsonic and supersonic velocities, Symposium on the vortex tube as a true free air thermometer, pp. 127-150; Chicago, Ill., Armour Research Foundation, May 1955.

Paper summarizes an experimental study of a tangential inlet, uniflow-type vortex tube similar to that reported in AMR **10,** Rev. The effect of tube geometry was studied and discussed. Some fifteen configurations were tried. Laboratory, wind-tunnel and flight data are presented. From the results it is concluded that a thermometer could be built to indicate true free air temperature to within ± 1 F up to Mach 1. This is better than other laboratories have been able to do. Above speeds of Mach 1, the thermometer was too inaccurate.

Data are also presented showing the operation of a thermometer having a two-element probe. This device was shown to be useful also as a Mach meter and a speed indicator. The value of the device was not fully appreciated by the Scientific Officer for the Government agency sponsoring the research and consequently, in reviewer's opinion, was not fully exploited. Reviewer was with ARF at the time this research was being conducted and, although their approach for the most part was rather unscientific, they were highly successful in achieving the desired objective, i.e., producing an accurate vortex thermometer.

R. J. Mindak, USA

2300. Stiefelmaier, C. A., NRL vortex thermometer installation and reliability experience, Symposium on the vortex tube as a true free air thermometer, pp. 151-167; Chicago, Ill., Armour Research Foundation, May 1955.

Author summarizes results of a two-year study program of two NRL vortex thermometers (described in papers 6 & 7) installed on two Boeing 377 airplanes of Pan American World Airways. A diary of the service troubles encountered and typical flight data were presented. The instrument was found to be quite useful in anticipating changes in power, carburetor and cowl settings resulting from changes in atmospheric conditions.

R. J. Mindak, USA

2301. Feenberg, Ya. M., and Kudryavtsev, I. S., The measurement of temperature pulsations in the exhaust systems of internal-combustion engines (in Russian), *Issledovanyie rabochikh protsessov v dizelyakh.* Moscow/Leningrad, Mashgiz, 37-56, 1954; Rev. no. 1431, *Ref. Zh. Mekh.* 1956.

The article deals with the measurement of the temperature pulsations in the exhaust lines of automobile internal-combustion engines.

An apparatus is described, developed from analytical considerations and experimental results obtained with resistance thermometers. The essential part of the apparatus is a transmitter, the sensitive element of which is a tungsten filament with an addition of thorium, of a diameter of 25 microns. The temperatures are recorded by means of an oscillograph loop.

Courtesy of Referativnyi Zhurnal From authors' summary
Translation, courtesy Ministry of Supply, England

2302. Land, T., Suction pyrometry, *Instrum. and Automat.* **29,** 7, 1314-1320, July 1956.

Thermocouples measuring gas temperature must be protected from radiant heat transfer to or from surrounding walls, and the hot gas must be moved rapidly past the thermocouple. The result is a suction pyrometer. The work described has resulted from friendly cooperation between the author's company and two research associations—the British Iron & Steel Research Association (B.I.S.R.A.) and the British Coal Utilization Research Association (B.C.U.R.A.). From author's summary

2303. Alban, C. F., and Perry, C. C., A new approach to the optimum design of thermostatic bimetal elements, *Mach. Design* **29,** 4, 119-123, Feb. 1957.

2304. Griffiths, W. H. F., Decade air condenser. Part I, II, *Engineer, Lond.* **202,** 5260, 691-693, Nov. 1956; **202,** 5261, 728-731, Nov. 1956.

In response to many requests for the simplification of the scaling of variable air condenser standards, author has designed and developed a decade air condenser which may be used with confidence to extend the range of a variable air condenser by one or two decades. In effect, this solution simplifies the problem of scaling by ten or one hundred times respectively and eliminates most sources of scale-reading inaccuracy as well as those of erroneous interpretation of reading.

This article is devoted entirely to the design of the decade of air capacitance and the virtual elimination of all sources of uncertainty of capacitance which might occur. The conventional variable air condenser of the rotating interleaved plane plate type is used as the basis of design and, because of this, ill-defined angular settings of one plate system relative to the other at any decade position must not be allowed to affect the capacitance at that position. Various methods are described of insuring capacitance stability despite angular uncertainty, and the various stages of improvement from the simple variable air condenser are given quantitatively by means of curves of C and $dC/d\theta$.

From author's summary

2305. Doumas, M., and Huste, A., Spray dryer design calculations, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-186, 20 pp.

A technique for calculating the size of a spray dryer required to dry a given drop size is presented. Basically, this technique involves calculating the trajectory of the drop through the air stream while simultaneously estimating the water-evaporation rates from the drop. The mechanism of drying of the drop and the effects of changes in dryer-operating conditions are discussed as a basis for the assumptions used in the calculations.

From authors' summary

2306. Straub, H. E., Gilman, S. F., Konzo, S., Distribution of air within a room for year-round air conditioning—Part I, *Univ. Ill. Engng. Exp. Sta. Bull.* 435, 48 pp., 1956.

In general, the major conclusions from this study can be summarized as follows:

(1) No single type of outlet provided optimum air distribution for year-round air conditioning.

(2) During heating the most acceptable distribution was obtained from outlets which were located in or near the floor and directed the air horizontally across the floor, or which directed the air vertically with considerable spread. The latter type gave acceptable performance over a wide range of flow rates and supply air velocities.

(3) During cooling the most acceptable distribution was obtained from outlets which were located near the ceiling and discharged the air horizontally, or from outlets located in or near the floor which directed the air vertically with little spread.

(4) During year-round air conditioning, if more importance were to be attached to the heating performance, a preferred outlet would be that which introduces the air vertically, with considerable spread, from a position in or near the floor. If more importance were to be attached to the cooling performance, a preferred outlet would be that which introduces the air vertically, with little spread, from a position in or near the floor or one which introduces the air horizontally from a position near the ceiling. It should be realized that the preferred outlet for one season will only be a compromise for the other season.

(5) The fact that a given type of outlet is preferred for heating or cooling does not imply that the other types of outlets cannot be used to give satisfactory performance. With such other outlets many factors involved in the design of a system need more careful consideration than when the preferred outlet is used. For example, neither the supply air velocities nor the flow rates can be varied over as wide a range as is permissible with the preferred outlet.

(6) During heating or cooling if an outlet produced uniform temperature distribution with little stratification, the location of the return intake had only a limited effect on the distribution. Under these conditions, the performance of a system with a single return intake would be practically the same as for a multiple-return system, but the installation would be greatly simplified.

From authors' summary

2307. Christianssen, T. G., Computation of heat exchange for steam-gas mixtures (in Swedish), *Tekn. Tidskr.* **87,** 3, 47–50, Jan. 1957.

2308. Krapivin, A. M., An investigation of the hydrodynamics of water-jet heat exchangers (in Russian), *Trudi Dnepropetr. in-ta inzh. zh-d. transp.* no. 24, 115–135, 1954; Rev. no. 896, *Ref. Zh. Mekh.* 1956.

Results are analyzed of a series of tests with water-jet heat exchangers, in which an interaction takes place between a water jet and a steam flow, accompanied by condensation of the steam and heating of the water. These investigations show the insufficiency of the theory of a heat-exchanger flow as the flow of a single-phase fluid, and the necessity of introducing considerations of the state change in the substance. A simplified method of calculating the thermal and hydrodynamic conditions in a water-jet heat exchanger is suggested, applying the equations of momentum, conservation of energy, continuity and several thermodynamic relationships.

An experimental investigation has been made of a water-jet heat exchanger with different working nozzles. The pressure distribution in the flow section of the heat exchanger has been measured. A glass model has been used to exhibit the qualitative picture of the heat-exchanger flow as well as the shape of the jet, its distortion under various back pressures behind the diffuser, etc.

As a result of these investigations, the high hydrodynamic qualities of the heat exchanger have been established. It has been found that, with increased pressure behind the diffuser, the structure of the water jet is changed. Conclusions are drawn regarding the influence of structural details of the heat exchanger, and a simplified method of determining the maximum water pressure behind the diffuser is given. Yu. F. Dityakin, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2309. Plisskin, G. I., Use of the equivalent rate of concentration in analyzing stage systems of evaporation (in Russian), *Teploenergetika* **3,** 1, 35–38, Jan. 1956.

2310. Lundgren, C. E., and Seippel, C., Thermal problems of atomic power stations, *Combustion* **28,** 8, 51–58, Feb. 1957.

Combustion

(See also Revs. 2276, 2285)

2311. Yamazaki, K., Burning velocity of premixed gases in relation to rate of active radicals formation, *J. chem. Soc. Japan, Indust. Chem. Sect.* **60,** 121–123, Feb. 1957.

Author calculated the activating free energies, enthalpies as well as entropies, needed for the formation of activated radicals of fuels at their flame temperatures; he assumes the rate of formation of active radicals to be inversely proportional to the delay of formaldehyde formation in pre-flame reactions. The calculated results show that the burning velocities of fuels increase with decreasing free energy changes for the activation at 1500–2000 K. He also classifies fuels into two groups according to the sign of entropy change for the activation. Fuels of negative entropy change have less probability of producing active radicals than those of a positive one. Isooctane, acetone, toluene, or isopropylether belong to the former, and benzene or ethylalcohol belong to the latter. T. Hikita, Japan

2312. Fine, B., Stability limits and burning velocities of laminar hydrogen-air flames at reduced pressure, *NACA TN* 3833, 29 pp., Nov. 1956.

Premixed hydrogen-air is burned at pressures from 74 cm Hg to 16 cm Hg at fuel-air ratio 0.8 to 2.0 times stoichiometric. Burner diameter 0.331 to 1.459 cm is chosen inversely proportional to pressure. Reynolds numbers ranged from 850 to 2100, far greater than for nearly quenched flame. Test conditions are far from blowoff. Maximum burning velocity of 304 cm/sec is obtained at 1.95 times stoichiometric, one atmosphere. Burning velocity, $U_b \propto P^{n_u}$ over composition and pressure range; P is pressure. Value of n_u varied randomly between 0.208 and 0.256, composition 1.1 to 1.95 of stoichiometric.

Flashback velocity gradient, $g_f \propto P^{n_f}$ where $n_f = 1.35 \pm 0.08$ for 0.95 to 2.25 of stoichiometric. At 0.80 stoichiometric, $n_f = 2$. Author suggests lean hydrogen-air flames exhibit peculiar behavior because of unusually high hydrogen diffusivity. n_f of 1.35 gives reaction order of 2.25 ± 0.09. n_u of 0.23 gives reaction order of 2.32 to 2.36.

Equipment design and operation seems to reviewer to result in uncertain description of conditions surrounding flame, with proportions of combustion products and ambient air dependent on manipulation of bleed to vacuum pump. Walls of chamber are considerable distance from flame; thus conditions are intermediate between shielded flame and open flame.

D. Aronson, USA

2313. Grumer, J., Harris, Margaret E., and Rowe, Valeria F.,

Fundamental flashback, blowoff, and yellow-tip limits of fuel gas-air mixtures, *U. S. Bur. Mines, RI* 5225, 199 pp., July 1956.

The combustion characteristics of a number of fuel gases have been studied fairly extensively by the authors, and by other investigators such as Lewis and Von Elbe and their collaborators Authors have made a critical analysis of most of the data available. The phenomena of flashback, blowoff, and yellow tipping as they occur in simple burners are discussed. Only the results from premixed streams of fuel gas (hydrocarbons, hydrogen, CO, etc.) and air are considered. The burners used had ports of circular, triangular, square, or rectangular cross section. The fuel flows were adjusted to give a stable flame, and the flow was then varied until flashback, blowoff, or yellow tipping was observed. The concept of "critical boundary velocity gradient" is used in discussing the results. The "boundary velocity gradient", seconds, is the rate of change of stream velocity at the edge of the stream mixture at the exit plane of the burner port.

Numerous graphs and tables are given for critical boundary velocity gradients for different fuels, and the regions of flashback, stable flames, yellow tips, and blowoff are marked on the graphs. Critical boundary velocity gradients for a few fuels at various temperatures (300 - 625 K) have also been plotted.

A. D. Yoffe, England

2314. Denniston, D. W., Jr., Oxendine, J. R., Knapschaefer, D. H., Burgess, D. S., and Karlovitz, B., Applications of the electronic probe to the study of turbulent flames, *J. appl. Phys.* **28,** 1, 70–75, Jan. 1957.

Description is given of a negatively biased bare wire probe with suitable amplification and pulse-height discrimination to be used in detecting flame fronts in turbulent motion. Typical measurements are given of a Bunsen flame's most probable position, its rms displacement from this position, and its degree of continuity during unstable burning. The treatment of data and the precision and limitations of the method are discussed.

From authors' summary by L. S. G. Kovasznay, USA

2315. Stark, S. R., The influence of the outlet cross section of a burner nozzle on the aerodynamics of the burner (in Russian), *Sb. Mosk. in-ta stali no.* 22, 167–191, 1954; Rev. no. 1553, *Ref. Zh. Mekh.* 1956.

A method is suggested for calculating the free jet of a gas issuing from an aperture of noncircular form, based on generalization of the results of experimental investigations. According to this method, where the transverse dimensions of the outlet cross section are not very different from each other, the calculation can be performed on the basis of the laws applicable to the equivalent, axially symmetrical jet; in this regard, the diameter of such equivalent axially symmetrical jet must be determined from the condition of equality of the quantity of motion for the hydrodynamic calculations, and the condition of equality of the quantity of excess heat for the thermodynamic analysis.

In the case of outflow from an extended orifice of rectangular form, the nondimensional values of the velocity and temperature at any point in the flow are determined as the product of the correspondingly nondimensional velocities and temperatures of two imaginary, two-dimensional jets intersecting at right angles; in this case, the thickness of the issuing jet is correspondingly equal to the height and the width of the particular aperture (orifice).

V. E. Doroshenko, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2316. Ceely, F. J., and Wheater, R. I., An effort to use a laboratory test as an index of combustion performance, ASME-AIME Joint Fuels Conf., Washington, D. C., Oct. 1956. Pap. 56–FU–6, 8 pp. + 8 figs.

Paper discusses results of a study in progress to determine if the CRL Reactivity Test can be applied as an index of combustion performance in pulverized-fuel-fired steam generators. Before undertaking an extensive program of correlating laboratory data against actual combustion experience, it was necessary to conduct the study on a limited basis to establish whether or not the results would justify an extensive effort. The authors present some significant data accumulated during this study phase and conclude that further investigation is warranted on a larger scale.

From authors' summary

2317. Grobman, J. S., and Dittrich, R. T., Pressure drop and air flow distribution in gas-turbine combustors, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–208, 21 pp.

Generalized curves showing the combustor total-pressure-loss coefficient and air-flow distribution for various geometric configurations and operating conditions were obtained from theoretical calculations. The results pertain to tubular turbojet combustors having (1) constant annulus and liner cross-sectional areas along the combustor axis and (2) flush circular holes in the liner walls.

From authors' summary

2318. Useller, J. W., Effect of turbojet compressor coolants on afterburner combustion, *Jet Propulsion* **27,** 1, 25–27, Jan. 1957.

Two methods of augmenting thrust of turbojet engines are injection of coolant at compressor inlet, and afterburning. When methods were combined, augmentation was less than expected because coolants reduced afterburner combustion efficiency as much as 20% and reduced outlet temperature. Effects of water-alcohol mixtures were somewhat different than effects of anhydrous ammonia, but both altered flame speed and reaction rate.

H. R. Hazard, USA

2319. Phillips, N. D., Progress report—ignitibility of solid fuels and burning rates of fixed carbon, ASME-AIME Joint Fuels Conf., Washington, D. C., Oct. 1956. Pap. 56–FU–5, 12 pp. + appendix + bibliography + 2 tables + 10 figs.

Results of preliminary combustion trials indicate that standard fuel analyses are not adequate for predicting furnace performance with the solid fuels now being obtained from certain new processes in the coal and petroleum industries. Paper describes laboratory tests and procedures that have been developed in an effort to obtain a more reliable indication of expected performance from these new fuels, which are chars formed during low-temperature carbonization of coal and petroleum cokes.

The ignition temperature test described is used to obtain data which have been found to correlate reasonably well with actual performance.

A method is shown for correlating fuel properties with unburned carbon loss in furnaces.

A laboratory method for determining a burning-rate index is described. Burning rates are correlated with unburned carbon loss data as an aid to the selection of proper combustion equipment.

From author's summary

Acoustics

(See also Revs. 2141, 2169, 2334)

2320. Levine, H., The torque on an infinite strip exposed to plane sound waves, *Proc. Camb. phil. Soc.* **53,** 1, 234–247, Jan. 1957.

A calculation of the torque is performed for an infinite strip exposed to plane sound waves, when the width is large compared to the wave length. It is shown analytically that the torque can reverse in sense as it approaches the zero value at vanishingly small wave length. This oscillation character is not to be found at long wave lengths where the torque acts only in the sense of aligning the strip broadside to the incident wave normal. The paper has application in the measurement of sound intensities when the wave length is comparable to the size of the measuring device.

W. P. Mason, USA

2321. Evans, E. J., and Bazley, E. N., The absorption of sound in air at audio frequencies, *Acustica* **6,** 2, 238–245, 1956.

Paper describes a determination of the sound-absorbing properties of air at frequencies from 1000 c/s to 12,500 c/s, for values of the relative humidity from about 5% to 85% of 20C. The measurements were made in a large reverberation chamber, in which the surface absorption was very small. The absorption due to the air was evaluated by an analysis of the results of measurements of the empty chamber absorption. The data obtained represent a revision of previously published results and are in close agreement with the relaxation theory. A general expression is derived for the attenuation of sound in air as a function of the frequency, humidity, and temperature.

From authors' summary

2322. Cedrone, N. P., and Curran, D. R., Electronic pulse method for measuring the velocity of sound in liquids and solids, *J. acoust. Soc. Amer.* **26,** 6, 963–966, Nov. 1954.

2323. Andreatch, P., Jr., and Thurston, R. N., Disk-loaded torsional wave delay line. I. Construction and test, *J. acoust. Soc. Amer.* **29,** 1, 16–19, Jan. 1957.

As compared with a conventional ultrasonic delay line in the shape of a uniform brass rod, a disk-loaded brass rod with alternate large-diameter and small-diameter sections propagates torsional waves with a considerably smaller speed, hence will delay a signal appreciably longer than a uniform rod of equal length. Authors describe design and machining of such disk-loaded lines, one of which was 3.0 inches long with disk diameters of 0.044 and 0.220 inch, the large disks being 0.015 inch thick and spaced 0.015 inch apart. A detailed description is given of the construction of the electromechanical transducers used to generate and detect the torsional waves at about 30 kc/sec; these were either of the split-tube type or of the disk-loaded ("dumbbell") type, made with a ceramic (containing mainly barium titanate) as the base material, and of smaller linear dimensions than the conventional low-frequency torsional transducers. For the above delay line with a 5 : 1 ratio of diameters, the measured delay was 114 μsec per cm of line at 32 kc/sec, as against only 4.5 μsec/cm for a uniform rod. R. Heller, USA

2324. Thurston, R. N., Disk-loaded torsional wave delay line. II. Theoretical interpretation of results and design information, *J. acoust. Soc. Amer.* **29,** 1, 20–25, Jan. 1957.

A mathematical analysis (based in part on work by H. T. O'Neil) of the magnitude of the delays reported in the preceding paper. The simple mathematical model of the line, employing inertialess shafts between rigid disks, is refined by allowing for the effects of distributed mass and elasticity in the disks. The disk-loaded structure is shown to be analogous to a tandem arrangement of identical low-pass filter sections. Agreement with the experimental values for the delay is satisfactory (92 as against 114 μsec/cm for the above line). To obtain complete agreement, the application of relatively simple empirical corrections to the dimensions should be possible after a sufficient number of tests. R. Heller, USA

2325. Numachi, F., Ultrasonic wave emitted by cavitation occurring on hydrofoils (in German), *Forsch. Geb. Ing.-Wes.* **22,** 3, 77–84, 1956.

Frequency spectra (namely the relation between the wave pressure and the frequency) of ultrasonic waves emitted by cavitation occurring on hydrofoil were measured with profile Clark Y, in cases of various values of the angle of incidence. It was possible to clarify how the spectra vary with the cavitation coefficient. From author's summary

2326. Veneklasen, P. S., City noise—Los Angeles, *Noise Control* **2,** 4, 14–19, July 1956.

2327. Boratynski, N., Plant planning for noise control, *Noise Control* **2,** 4, 37–46, July 1956.

2328. Fehr, R. O., Noise problems in testing turbojet engines, *Noise Control* **2,** 4, 32–36, July 1956.

2329. Blucher, W. H., City planning for noise control, *Noise Control* **2,** 4, 51–55, 80–81, July 1956.

2330. Knudsen, V. O., Community noise, *Noise Control* **2,** 4, 12–13, 90, July 1956.

2331. Bolt, R. H., Criteria for neighborhood noise control, *Noise Control* **2,** 4, p. 20, July 1956.

2332. Finch, D. M., The regulatory aspects of surface transportation noise, *Noise Control* **2,** 4, 28–30, 94, July 1956.

2333. Lassiter, L. W., and Hubbard, H. H., The near noise field of static jets and some model studies of devices for noise reduction, *NACA Rep.* 1261, 12 pp., 1956.

See AMR **7,** Rev. 4069.

2334. Howes, W. L., and Mull, H. R., Near noise field of a jet-engine exhaust. I—Sound pressures, *NACA TN* 3763, 51 pp., Oct. 1956.

The acoustical near field produced by the exhaust of a stationary turbojet engine having a high pressure ratio was measured for a single operating condition without afterburning. The maximum over-all sound pressure without afterburning was found to be about 42 pounds per square foot along the jet boundary in the region immediately downstream of the jet-nozzle exit. With afterburning the maximum sound pressure was increased by 50%. The largest sound pressures without afterburning were obtained in the frequency range from 350 to 700 cps.

Additional tests were made at a few points to find the effect of jet velocity on near-field sound pressures and to determine the difference in value between sound-pressure levels at rigid surfaces and corresponding free-field values. Near the jet nozzle, over-all sound pressures were found to vary as a low power (approx. unity) of the jet velocity. Over-all sound-pressure levels considerably greater than the corresponding free-field levels were recorded at the surface of a rigid plate placed along the jet boundary.

The downstream locations of the maximum sound pressure at any given frequency along the jet-engine-exhaust boundary and the longitudinal turbulent-velocity maximum of the same frequency along a small cold-air jet at 1 nozzle-exit radius from the jet axis were found to be nearly the same when compared on a dimensionless basis. Also, the Strouhal number of the corresponding spectra maximums was found to be nearly equal at similar distances downstream. From authors' summary

2335. Greatrex, F. B., Jet noise, Proc. Fifth International Conference, Los Angeles, June 20–23, 1955, 415–448; New York, Institute of the Aeronautical Sciences.

Toothed and corrugated noise-reducing nozzles were investigated, the latter proving better, with up to 12-db reduction obtained in one frequency band, and no thrust loss. Results are qualitatively explained by increased mixing obtained with corrugations; peak attenuation increases with their depth, and

frequency of maximum reduction with their number. Comparison of jet and propeller aircraft of same all-up weight indicates former is 9 db noisier at take-off. If paired jet engines are sufficiently close, noise increases about 1.5 rather than 3 db.

V. Salmon, USA

2336. Chavasse, P., and Lehmann, R., Some aspects related to the noise produced by modern airplanes (in French), *Acustica* **5,** 6, 289–297, 1955.

By means of a Laplace transform it has been possible to characterize satisfactorily, from a physical point of view, the reflection and transmission of a plane exponential wave with normal incidence to an elastic plate immersed in a liquid. Furthermore, the waves travelling inside the plate have been considered. It was then found that the transmitted as well as the reflected wave may be represented by a discontinuous function with a finite jump at times corresponding to twice the plate thickness. The theoretical results have been verified experimentally by studying the change of the exponential pressure-time curve produced by an underwater explosion in the case of reflection at and transmission through a concrete plate immersed in water. Tests have also been made with a combination of different plates, and the agreement between theory and experiment seems to be satisfactory. From authors' summary

Ballistics, Detonics (Explosions)

(See also Rev. 2027)

2337. Singer, S. F., The effect of meteoric particles on a satellite, *Jet Propulsion* **26,** 12, 1071–1075, Dec. 1956.

Three models are considered to calculate erosion effect of meteoric high-speed dust (50km/sec) on skin (e.g.,Al) of a satellite or space vehicle: (A) Meteor taken as collection of individual atoms, sputtering off atoms of skin. Result: 200,000 years needed for removing a layer of 10 μ; (B) by cooperative effects all meteor energy is used in sublimating atoms from skin; 1000 years for 10 μ; (C) As in sandblasting experiments, particles of skin are assumed to be chipped off; 1600 sec for 10 μ. Estimation of energy exchange during impact of a high-speed particle on skin shows that erosion rate is much greater than for models A and B, but probably somewhat smaller than for model C.

Laboratory experiments with artificially accelerated dust particles, which could furnish more reliable information, are discussed. An erosion experiment for Vanguard satellite, based on radioactive method, is described. Results could be used to study effect of sun on interplanetary dust. A. Kochendorfer, Germany

2338. Gore, M. R., and Carroll, J. J., Dynamics of a variable thrust, pump fed, bipropellant, liquid rocket engine system, *Jet Propulsion* **27,** 1, 35–43, Jan. 1957.

The principal dynamic characteristics of a pump fed, variable thrust, bipropellant, liquid rocket engine system are established over a broad thrust range by analog computer simulation of the nonlinear physical elements. Several basic types of control elements are studied, and a control system capable of meeting a stringent set of transient performance requirements is synthesized. The results of this study are of general applicability to rocket engine system design since the effect of the intrinsic system nonlinearities upon performance at various thrust levels is established. Transient and frequency response characteristics of the nonlinear system are determined for both small and large changes in thrust level. Correlation between the general nonlinear equations and the linear equations which describe the rocket engine system for perturbations about any fixed thrust level is shown. From authors' summary

Soil Mechanics, Seepage

(See also Revs. 2344, 2345, 2346, 2347, 2348)

Book—2339. Bekker, M. G., Theory of land locomotion, Ann Arbor, University of Michigan Press, x + 520 pp., $12.50.

2340. Descans, L., Some problems related to earth pressure (in French), *Ann. Trav. publics Belg.* no. 5, 5–32, 1955.

The correct solution of the problem of earth pressures would require finding a method which would offer not only the relation between stress distribution and deformation conditions, but which would regard also the special inhomogenous qualities of earth as a construction material. Author outlines a new method dealing with the problem only from the first point of view, but arrives at results which are on the safe side and are, therefore, well adaptable for practical use.

It is generally accepted, when dealing with the ultimate bearing capacity of subsoils, that the loaded earth mass may be divided into three zones, namely, the zones of active and passive earth pressure and the intermediate zone of radial shear. Based on the relation represented in Weyrauch's circle between the tensions and sliding-planes, author derives equations for the ratio of tensions acting upon the boundary planes of these zones. From these equations and based on the necessary equality of the ratios between the two boundary planes, he arrives at a ratio of q/p (where p is the active unit load under the foundation and q the unit counterload around the foundation). In this way he gives values where the stress-strain curve is still in the region of "great settlements" which precedes the condition of limit-stability and is, therefore, safer than the various theories based upon the consumption of shear-resistance along a continous sliding surface. Author then extends his theory to active and passive earth pressure problems and to the earth pressure in dams.

Article is a valuable contribution to the question when attacking the problem from an unusual side; and although it neglects such important factors as the own weight of the extruding earth mass, friction between earth and foundation and the foundation depth itself, it may give valuable help in practical work and a look into the complexity and general character of all earth pressure problems. C. Szechy, Hungary

2341. Rizaev, Sh. R., An instrument for determining the side pressure of soils (in Russian), *Dokladi Akad. Nauk SSSR* no. 12 33–36, 1954; Rev. no. 1670, *Ref. Zh. Mekh.* 1956.

Side pressure of the soil is measured by means of a pressure gage receiving the pressure of a liquid contained in a chamber built into the side-wall of an odometer, and separated from the sample by a rubber diaphragm. The soil sample is 30 mm high and 71 mm in diameter. The vertical pressure on the sample is obtained by means of a press.

Determinations have been made of the relationship between vertical and side pressures, for sandy loam of the loess type, and adobe, with and without previous swelling. The results of the tests are plotted as curves. M. V. Malishev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2342. Bathelt, U., Operational behavior of a vibrational compactor acting on plastic-elastic soil (in German), *Bautech.-Arch.* no. 12, 52 pp., 1956.

Soil compaction by vibration is accomplished using machines which transmit to the soil a series of impulses generated by the rotation of an eccentric mass.

Author derives in detail the mathematical theory of the compactor's motion when acting on (a) rigid and (b) elastic and plastic subgrades. For case (b) author replaces soil with a mechanical model having idealized elastic and plastic properties. After studying the influence of various parameters (masses of compactor and

engine, intensity and frequency of periodic impulses, etc.) on the energy transmitted from compactor to subgrade, author discusses the relationships these parameters must fulfill to obtain optimum operational behavior. Cases of abnormal behavior are also analyzed.

In the second part, author presents the results of experiments using a 2400-pound compactor on a sand and fill subgrade. Subgrade properties are not clearly described. Displacements and accelerations were measured and confirm generally the theoretical computations.

The article, which presents clearly the theory of vibrating compactors, is of principal interest for the machine designer; it has lesser interest for the soil mechanics engineer since geotechnical problems connected with the use of the compactor are given only marginal treatment. R. Jappelli, Italy

2343. Goberman, L. A., On the analytical determination of a skidding and spinning wheel with a rigid rim (in Russian), *Selkhozmashina* no. 3, 14–19, 1955; Rev. no. 1340, *Ref. Zh. Mekh.* 1956.

Assuming a linear relationship between the deformation of the soil and its stressing, author generalizes the problem of the determination of resistance to skidding of a wheel, investigated by V. P. Goryachkin for pure skidding, to include skidding with sideslip and spin. A. N. Obmorshev, USSR

Courtesy of Referativnyi Zhurnal
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Micromeritics

(See also Rev. 2211)

2344. Brillant, J., The discharge of flow in pervious soils bounded by a horizontal impervious substratum (in French), *Genie civ.* 133, 5, 95–97, Mar. 1956.

In axisymmetrical flow in region bounded by two vertical concentric circular cylinders with traces c_0, c_1, and by a horizontal impervious roof at height $z = m$, with known heads h_0, h_1 over the boundary, the discharge is given by three formulas (Dupuit), i.e., for (1) $m < h_1 < h_0$; (2) $h_1 < m < h_0$; (3) $h_1 < h_0 < m$. In the derivation, the head is assumed independent of z. This holds in (1), but for (2) and (3) it is an approximation.

The domain of application of these formulas—with the same approximation—was extended by Forchheimer to flow in regions bounded by vertical cylinders with traces c_0^*, c_1^*, conformal images of the circles c_0, c_1. Tcharnyi, and Vibert showed recently that formula for (3) in case of axial flow within circular boundaries is as rigorous as that for (1). Same can be shown for (2). Author establishes that Forchheimer's generalization still applies by showing that the functions involved are harmonic and admit a certain conjugate. He postulates Darcy's law (generalized) and a constant value k for permeability in any horizontal direction. The three formulas are now rigorous for regions bounded by vertical cylinders with traces c_0^*, c_1^*.

Discharge is independent of k_v permeability in vertical direction; this justifies application of formulas to problems of flow in alluvial strata. This is less legitimate in problems of water-table lowering by pumping, in alluvial deposits where $k/k_v > 1$.

G. H. Beguin, Switzerland

2345. Charny, I. A., and Rozenberg, M. D., Borehold interaction in conditions of elastic infiltration (in Russian), *Trudi-Moskov. neft. in-ta* no. 12, 184–201, 1953; Rev. no. 959, *Ref. Zh. Mekh.* 1956.

An examination of the problem of interaction between boreholes under elastic conditions of infiltration of the liquid, in a stream of infinite extent. In first paragraph a method is given for determining the pressure (or the density of the liquid) at any point in the stratum, provided the borehole pressures are known. The solution of the problem is related to the solution of a system of Volterra equations: if a Laplacian operator is applied to this system of integral equations, a system of linear equations is obtained, determining the conformal representations $Q_i(s)$ of the required delivery volumes $q_i(t)$.

In paragraphs 2, 3 and 4, the method of consecutive substitution of steady-state conditions is applied to the solution of the above problem. The problem of the interaction of an infinite system of boreholes in a stream of infinite extent is examined.

In paragraph 5, the results are correlated with the rigorous solutions for the cases of radial and rectilinear flow of the liquid. As is shown in the article, the method of consecutive substitution is found to be less accurate in the case of rectilinear infiltration, and shows an error of up to 25% in the sense of increasing the depression. M. A. Gusein-zade, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2346. Kursin, S. A., The transition from linear to nonlinear seepage (in Russian), *Nauch. zap. un-ta mashinoved. i avtomatiki Akad. Nauk USSR, avtomatiki i izmerit. rekh.* **4**, 3, 143–149, 1955; Rev. no. 967, *Ref. Zh. Mekh.* 1956.

An experimental investigation is made of the flow from orifices, flow around a sphere, and seepage through uncemented sands.

It is demonstrated that in all three cases there is a continuous relationship between the coefficient of resistance and the Reynolds number, with a gradual transition from a linear to a nonlinear state.

Author makes no attempt to generalize the particular results obtained by him and to link them with the numerous published data on this subject. The experimental results are merely plotted in curves, and cannot, therefore, be utilized for further analysis.

Author suggests a formula expressing the relationship between the coefficient of permeability and the porosity and effective diameter of the particles constituting the porous medium. This formula, confirmed by author's experimental investigations, is of only particular significance, and applicable only to uncemented sands with dense packing. E. M. Minskii, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2347. Guseinov, G. P., The two-dimensional radial inflow to a gas-laden petroleum borehold in the presence of a natural or artificial feeding contour (in Russian), *Dokladi Akad. Nauk Azer. SSR* **10**, 2, 79–85, 1954; Rev. no. 1583, *Ref. Zh. Mekh.* 1956.

The problem of the two-dimensional radial displacement of petroleum by water under sustained, constant pressure, along a plane in the stratum coinciding with the original line of contact between the water and the petroleum, has already been investigated in the relevant literature [*Ref. Zh. Mekh.* 1954, Rev. no. 2210; 1955, Rev. no. 5091]. Using the method given in these references, author gives an approximate solution for the mechanical displacement of petroleum by water, with a somewhat different condition on the movable interface.

A comparison is given between the results of calculation of a numerical example and the results calculated in an article by M. M. Glogovsky and M. D. Rosenberg [*Ref. Zh. Mekh.* 1955, Rev. no. 5091]. This comparison shows considerable divergence. In this particular example, author has incorrectly intergrated the differential equations, which makes his conclusions unconvincing.

Author arrives at the conclusion, already formulated in the above-mentioned papers, that, after a certain period of time, the gas-laden petroleum displaced by the water, under the particular conditions investigated, moves practically in the manner of an incompressible fluid. M. D. Rozenberg, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2348. Peyros, M., II, An analysis of methods of evaluation of investigations on boreholes (in Russian), *Trudi Vses. neftegaz. n.–i. in-ta* no. 6, 270–278, 1954; Rev. no. 1584, *Ref. Zh. Mekh.* 1956.

A description is given of a method suggested by Miller, Dyes and Hutchinson [*Petrol. Technol.* **2**, 4, 81–104, 1950] for the determination of the permeability from the curves of pressure recovery in the abandoned borehole. The permeability values for a number of boreholes in an extensive field are determined by this, and other, methods.

The values obtained by the method suggested by the above authors satisfactorily agree with the permeability values calculated by other methods. Nevertheless, the present author does not recommend this method for practical use in view of the close relationship between the result obtained and the particular, arbitrary feeding contour. A. M. Pirverdyan, USSR

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Translation, courtesy Ministry of Supply, England

2349. Skobeev, I. K., The problem of filtration of mining sludges (in Russian), *Trudi Irkut. gorno-metallurgich. in-ta.* no. 1, 34–85, 1954; Rev. no. 328, *Ref. Zh. Mekh.* 1956.

This paper contains nine sections. 1. Introduction. 2. Filtration equation. 3. Performance of filters. 4. The work of filter fabrics. 5. Rate of rotation of continuous acting filters, and their degree of immersion in the sludge. 6. Thickness of the cake layer, and the effective duration of filtration operations on periodic filters. 7. The degree of vacuum in the cavity of a filter and the consumption of air. 8. Calculation of the output of filters. 9. The rinsing of cakes on filters

By integration of the equation of the growth of the layer thickness of the precipitate on the filter

$$\frac{dh}{dt} = \frac{KP}{AR_0(h - h_0)}$$

relationships were obtained for determining the collection time of the layer of precipitate (cake) of a given thickness

$$t = \frac{AR_0\, h(h + 2h_0)}{2KP} \qquad \text{(min)}$$

of the mean rate of filtration

$$w = \frac{2KP}{2h_0 - h} \qquad \frac{\text{mm}}{\text{min}}$$

and the duration of rinsing the precipitate

$$t_n = \frac{AR_n h(h + h_0)}{KP} \qquad \text{(min)}$$

(h) is the thickness of the layer of precipitate in mm, R_n the consumption of rinsing water in m^3 per T of solid, P the pressure drop during filtration or degree of vacuum in a tin, A the volumetric weight of the precipitate taken as a solid, T/m^3, R_0 the volume of the filtrate per unit of solid in a precipitate m^3/T, K the constant of rate of filtration h_0 the thickness of the layer of the precipitate the hydraulic resistance of which is equivalent to the thickness of the filter fabric in mm). The values of the constant of rate of filtration were determined for various sludges. For argilacious cyano-sludge, K was equal to 4.5 to 6.0 mm^2/min.atm. For quartz sludges with a fineness of 140μ, K = 70 to 90. For flotation sulphide concentrates (74μ) K = 100 to 150 mm/min. atm.

Courtesy of Referativnyi Zhurnal V. A. Klyachko, USSR
Translation, courtesy Ministry of Supply, England

2350. Oatley, C. W., The flow of gas through composite systems at very low pressures, *Brit. J. appl. Phys.* **8**, 1, 15–19, Jan. 1957.

2351. Zaitsev, M. M., and Teverovsky, E. N., A high-speed dust catcher, absorber, and heat exchanger (in Russian), *Khim. prom-st* no. 2, 18–23, 1955; Rev. no. 927, *Ref. Zh. Mekh.* 1956.

An instrument is described for the precipitation of dust from a gas flow, called by the authors a "turbulent gas-washer". The apparatus consists of a venturi tube, connected with a droplet-type cyclone separator.

The cleansing or scrubbing of the gas takes place by means of a liquid introduced into the venturi tube in the form of a jet, or of dispersed droplets.

It is recommended to dimension the venturi tube in standard sizes, insuring least (flow) resistance. The angle of the contracting part should be 25–60°, of the diffuser 6–7°. The liquid can be introduced into the tube through apertures situated on the circumference of the contracting part, or by means of pipes entering that part, or ending in front thereof. The minimum diameter of such a liquid-feed orifice is prescribed as 4–6 mm, to prevent obstruction during working. The rate of feed of the liquid should be so selected that the droplets shall be able to occupy the entire cross section of the apparatus.

Test results are given, showing that the turbulent scrubber is 98–99% efficient in intercepting dust. The interception of dust is only slightly dependent on the rate of flow in the venturi throat, and practically independent of the nature of the gas feed (centrally or peripherally to the convergent part).

Data are also given, from various sources, of the industrial use of such scrubbers for cleaning different gases from dust and smoke.

It is shown that the presence of a large, free water surface in the scrubber, dispersed in minute droplets, and its intensive mixing, effects a very thorough cooling of the gas.

Courtesy of Referativnyi Zhurnal E. M. Minskii, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Meteorology, Oceanography

2352. Atlas, D., and Kessler, E., III, A model atmosphere for widespread precipitation, *Aero. Engng. Rev.* **16**, 2, 69–74, Feb. 1957.

It is important to know the amount of water and snow being precipitated at different altitudes of the atmosphere for many problems such as jet-engine water and ice ingestion, and masking of radar targets by precipitation. From moisture continuity reasoning, authors have developed a series of models showing vertical distribution of precipitation intensity, and also vertical distribution of spatial concentration of precipitation with height. The latter is considerably affected by slowly falling snowflakes; mass concentrations as high as 8 gm/m^3 have been computed for the middle troposphere, using a precipitation rate of 10 mm/hr at the ground. Precipitation content is highest between 10,000 and 20,000-ft altitude for all models with sizeable precipitation. The rainfall rate-altitude diagram for 10 mm/hr can be conveniently interpreted in terms of per cent. Particle-size distribution, and radar reflectivity as a function of height for the models are also discussed. H. Riehl, USA

2353. Fett, W., A new measurement device for high-altitude winds (in German), *Z. Meteor.* **10**, 7, 207–216, July 1956.

2354. Bohme, W., Momentum exchange in the higher troposphere and zero layer effect (in German), *Z. Meteor.* **10**, 1, 12–22, Jan. 1956.

2355. Uspensky, B. D., The theory of local variation of geopotential heights on isobaric surfaces (in Russian), *Meteor. i. gidrologiya* no. 5, p. 308, 1954; Rev. no. 1561, *Ref. Zh. Mekh.* 1956.

A simplified formula is derived for the local variation of the isohypse on the assumption that the values of the two-dimensional divergence are calculated directly from the wind field. It is demonstrated that the formula can also be applied for qualitative analysis of the change of the pressure field.

It should be noted that, with the presently available accuracy in the measurement of wind speeds and their plotting on synoptic charts, calculation of the two-dimensional divergence may be accompanied by considerable errors. In the derivation of the formula, instead of the solution of the Poisson equation $\Delta u = f$, author uses the approximate relationship $\Delta u = -mu$, where m = an empirically selected constant. This eliminates the influence of adjacent areas on the change in elevation of the isohypses at the point in question. E. M. Dobpishman, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2356. Wieland, V., Water-vapor condensation on natural aerosols in low saturation region (in German), *ZAMP* **7**, 5, 428–460, 1956.

Low-degree supersaturation of water-vapor condensation around natural aerosols was measured by means of 2 m long, 40-mm diam warm rod and warm block. It is concluded that aerosol near ground surface always contain sufficient active nuclei which form condensation in region RH 100 ~ 101%, and nuclei size and nuclei activity are parallel in low-degree supersaturation. Though these conclusions were derived from special experimental apparatus, they are of considerable interest in supersaturation condensation. H. Arakawa, Japan

2357. Reuter, H., The present state of art in numerical weather forecasting (in German), *Öst. Ing.-Arch.* **10**, 2/3, 252–260, 1956.

2358. Tuzson, J., Theory of cyclones. Parts I, II (in French), *Rev. gên. Mécan.* **39**, 82, 367–374, Oct. 1955; **39**, 83, 401–407, Nov. 1955.

Lubrication; Bearings; Wear

(See also Rev. 2023)

2359. Pinkus, O., Analysis of journal bearings with arbitrary load vector, ASME-ASLE Lub. Conf., Atlantic City, N. J., Oct. 1956. Pap no. 56-LUB-2, 7 pp.

By the use of an IBM digital computer, author obtains theoretical solutions of Reynolds equation for finite journal bearings which have two axial grooves at the horizontal split and two bearing arcs of 150° each. The equation is solved for various specified geometrical configurations with the imposed condition that the pressure nowhere falls below atmospheric; the corresponding values of the Sommerfeld number and the directions of the resultant load vector are thence deduced. The oil flow rate and the power loss for each set of conditions are also computed. Constant viscosity is assumed in all calculations. From the results it is shown that for a particular design of bearing there is a direction of loading which gives nearly the greatest load capacity and lubricant flow, and the least power loss. G. D. S. MacLellan, England

2360. Tipei, N., Contributions to the study of hydrodynamic lubrication (in French), *Rev. Mecan. appl.* **1**, 1, 107–139, 1956.

Present paper summarizes nine previous papers by the author in Rumanian language (not available to reviewer).

The basic equations of the theory of lubrication are written, taking into account (1) fluid (oil or gas) compressibility and (2) possible variation of pressure (a linear variation resulting at the end) along the normal to lubricated surfaces. Moreover, fluid viscosity is supposed to be proportional to a given power q of film thickness δ (which, reviewer thinks, should take into account viscosity variations due to heat produced by friction losses). Indications for integration in general case are given.

For lubricating incompressible oils and neglecting variation (2), equations are integrated for any q and finite width of lubricating films in form of much involved power series. Closed simple approximated formulas are nevertheless obtained in the following cases: (I) Journal bearing with lubricated efficient arc = 180° and < 180° (partial, "with no radial clearance," bearing); (II) plane slider bearing; (III) shaft and bearing with variable diameter and clearance (cases I, II, III with constant load and speed); (IV) journal bearing with variable load (crankpin).

Paper meets and overcomes many mathematical complications and presents a general idea of the effect of variable viscosity. Nevertheless, owing to excessive conciseness (particularly in explaining basic hypothesis) and also to some unexplained symbols, several points are not clear (e.g., the assumptions about the extension of effective lubricated arcs in journal bearings; the assumed law for viscosity variations). The original quoted papers could probably, if available, better explain and justify procedures and results. R. Giovannozzi, Italy

2361. Tabin, N. V., and Vinogradov, G. V., The immersion of a flat wedge in a consistent lubricant (in Russian), *Trudi Kazansk. khim.-tekhnol. in-ta* no. 18, 222–229, 1954; Rev. no. 1642, *Ref. Zh. Mekh.* 1956.

The kinematics and dynamics of the immersion of a wedge in a consistent lubricant are examined by polarisation optics. From analysis of the arrangement of the interference bands, the region of flow is determined, and the limit of the region of boundary shear stress along the edges of the wedge.

Courtesy of Referativnyi Zhurnal N. I. Malinin, USSR
Translation, courtesy Ministry of Supply, England

Marine Engineering Problems

(See also Revs. 2038, 2104)

2362. Du Cane, P., The planing performance, pressures, and stresses in a high-speed launch, *Trans. Instn. nav. Arch. Lond.* **98**, 4, 469–490, Oct. 1956.

Paper presents design, construction, and trial-run evaluation information on a 68-ft high-speed air/sea rescue launch built of aluminum with fiberglass side panels. The launch provided a basis for evaluating the relative merits of the new construction materials.

Performance figures, planing bottom pressures, accelerations, and stresses are given along with a description of the instrumentation. The results should aid designers of such craft. Report indicates that aluminum-alloy construction can be used in a field where wood or plywood has previously been used. This should yield some saving in weight. W. C. Hugli, USA

2363. Sukhomel, G. I., Zass, V. M., and Yankovsky, L. I., On the resistance and change of trim (squatting) of vessels moving in canals and rivers (in Russian), *Vopr. nauch. boosnovaniya str-va Kakhovskogo gidrouzla. Kiev. pub. Akad. Nauk USSR*, 66–84, 1954; Rev. no. 875, *Ref. Zh. Mekh.* 1956.

A brief account is given of an approximation method for calculating the first critical speed and the fall in level of the free surface at the vessel, as well as the change of trim or squat of the latter, in travelling along shallow channels, founded on the hydraulic considerations enunciated by G.I. Sukhomel. The calculated results are summarized in tables and compared with the results of model tests. Data are also given for full-scale tests with a twin-screw diesel tug on the R. Dnieper and one of its

tributaries (R. Konka). The satisfactory agreement of the experimental results with the calculations by the unidimensional hydraulic theory is stressed. M. D. Khaskind, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2364. Miroshnichenko, I. P., Resistance and speed of ships with displacement bilge keels (in Russian), *Trudi Tsentr. n.-i. in-ta rech. flota* no. 27, 3–28, 1954; Rev. no. 1505, *Ref. Zh. Mekh.* 1956.

The results are presented of experiments made at the request of the Central Scientific Research Institute of the Merchant Navy in the testing tank of the IKI, on two groups of ship models of original forms suggested by A.K. Osmolovsky [*Vodny Transport*, 1939 (11),] for mixed river and sea navigation. In addition to data on wave resistance, diagrams are given of the wave forms along the sides of the model hulls. Details but not always conclusive arguments are put forward on the basis of the experimental results, from which the author concludes that bilge tanks, if correctly placed, can usefully improve the seagoing qualities of a ship's hull. V. M. Lavrent'ev, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2365. Hamilton, J. A., and Gigg, R. V., The full-scale hydrodynamic performance of a large four-engined flying boat at overload in calm water and swell, *Aero. Res. Counc. Lond. Rep. Mem.* 2898, 38 pp., 1956.

Tests have been made on a large four-engined flying boat (*Solent* Mk. 3) to determine the hydrodynamic performance in sheltered water and in open-sea swells. The sheltered water characteristics were investigated over a range of weights between 72,000 and 84,000 lb. The performance in swell covered weights up to 82,000 lb, and swell heights up to 5 ft. The latter tests were made at Gibraltar in February, 1951.

The main conclusions of the investigation which may be applied generally to hulls similar to the *Solent* can be summarized as follows:

(a) *In sheltered water* (i) the hydrodynamic longitudinal stability and spray are acceptable in calm water at a C_{Δ_0} of 1.2 (84,000 lb weight for the *Solent*); (ii) short seas up to 4 ft in height have relatively little effect on hydrodynamic performance; (iii) acceleration through the hump region has a considerable effect on the acceptable amount of porpoising, and the limiting out-of-wind angle for take-off. For military aircraft, a minimum take-off acceleration of 0.1 *g* is recommended.

(*b*) *In ocean swell* (i) violent porpoising may occur on a normally stable hull, if operated into ocean swells of length greater than the aircraft length, and height greater than 1 to 1½ ft; (ii) swell height does not appear to affect the stability greatly (limits tested, 1 to 5 ft); (iii) the porpoising motion is relatively insensitive to weight, but increased take-off acceleration at lower weight reduces the extent of the unstable region; (iv) operation along the swell produces no instability; (v) the presence of wind may reduce swell porpoising considerably. From authors' summary

2366. Hamilton, J. A., A full-scale investigation into the hydrodynamic behaviour of a highly faired flying-boat hull, *Aero. Res. Counc. Lond. Rep. Mem.* 2899, 36 pp., 1956.

Report describes an investigation into the hydrodynamic qualities of a *Sunderland* flying-boat hull, weight 50,000 lb, fitted with a main-step fairing of fairing ratio 17:1. The fairing was equipped with ventilating ducts, drawing air at atmospheric pressure through ports on the hull side, and discharging it through exit vents on the afterbody planing bottom. No pumping apparatus was fitted, the airflow being induced by the sub-atmospheric pressures on the fairing.

The main conclusions of the investigation may be summarized in this manner:

(*a*) A highly faired hull of this kind is hydrodynamically satisfactory, with a ventilating area equivalent to 0.042 (beam)^2 placed immediately behind the main step line.

(*b*) For satisfactory hydrodynamic behavior, the step line, *i.e.*, the junction between forebody and afterbody, must be kept sharp, but only an angular discontinuity in the vertical plane is necessary.

(*c*) Without ventilation, the highly faired hull exhibits severe hydrodynamic instability during take-off and alighting, and the resistance is about 30% higher than the ventilated hull.

(*d*) Pressure measurements on the afterbody indicate that skipping instability is caused by the presence of a region of sub-atmospheric pressure, covering almost the whole afterbody during skipping, and having maximum suctions of up to 4 lb sq in. occurring at about 0.4 beam lengths aft of the step line.

The general conclusion of the investigation is that successful hulls may be designed without conventional steps, provided that sufficient internal ventilation is provided.

From author's summary

2367. Van Manen, J. D., Some remarks on the conditions for minimum energy loss in marine propellers, *Inter. Shipbldg. Progr.* **3,** 26, 547–550, Oct. 1956.

Author formulates the conditions under which the losses of an operating ship propeller become a minimum with a given diameter of the propeller D, a given power N, and a given translational velocity v_e.

The conditions for minimum energy losses are formulated both for ship propellers working in a homogeneous field and for propellers working in a radially unequal velocity field.

The approximate calculations are referred to the velocity field which should be set up at the infinitely shall blades of the propeller, if these small blades carry the load of the given propeller blades. The calculation is referred to the thrust and tangential forces which act on infinitely small cylindrical cutouts of the propeller blades.

Reviewer remarks that, – the case of highly-loaded wide-blade ship propellers, the influence of the *distribution* of the induced velocity at *the surface of the blade* (components c_u, c_a, and c_r) is important both with respect to the energy losses and to the form of the blade. For this reason, to calculate the blade form of highly-loaded wide-blade ship propellers, the distribution of the three components of the velocities induced by the free vortexes are usually taken into consideration both in cylindrical and in radial cross sections of the blade. [See also M. Strscheletzky, "Design charts for three-bladed ship propellers," Karlsruhe 1955.]

M. Strscheletzky, Germany

2368. Lerbs, H. W., Contra-rotating optimum propellers operating in a radially non-uniform wake, *David W. Taylor Mod. Basin Rep.* 941, 26 pp., May 1955.

2369. Lerbs, H. W., Propeller pitch correction arising from lifting surface effect, *David W. Taylor Mod. Basin Rep.* 942, 17 pp., Feb. 1955.

2370. Thieme, H., Mechanics of sail propulsion; Contribution to the study of the performance possibilities of sailing boats (in German), *Jahrbuch Schiffbautech. Gesellsch.* **49,** 306–352, 1955.

The motion of a sailing boat is examined from a theoretical standpoint. To provide a basis for analysis, the kinematics of motion across the sea surface are reviewed considering effects of wind and water current. Relationships between various relative velocities are developed and conditions required for maximum velocity are proven. Most of paper is a detailed consideration of the dynamics of sailing. Forces induced on sails by the wind are

reviewed and experimental values introduced. Effects of sail shape, interference, and flapping are considered in detail. Values of resistance and other coefficients realized in practice are given. Hull resistance and characteristics are not considered in the detail given to other aspects. This is a relatively well-known phase of the problem, having been studied in other fields of naval architecture.

Author presents values realized in yachts of various size and design. Many other topics related to sailing-boat performance are also reviewed at end of paper and a statistical review of velocities attained by yachts is presented. An extensive bibliography of the mechanics of sailing completes the paper.

Reviewer finds paper well written and easy to follow. It should prove of value to any technically trained person who is interested in sailing. W. D. Baines, Canada

2371. Yamanouchi, Y., Analysis of ships' oscillations as a time series (in Japanese), *J. Soc. nav. Arch. Japan* **99**, 47–64, July 1956.

The time-series analysis is proposed as a suitable method of treating the forced oscillations of ships that are steaming among irregular seas and winds. With some actual records of oscillations of a Japanese train ferry ship, the correlograms and the periodograms are calculated, and then, making a Fourier-cosine inversion, the spectrum of the ship's oscillations is obtained. The required information about a ship's free oscillations, as well as the construction of the external force due to seas and winds, is clarified through the analysis. T. Inui, Japan

2372. Comstock, J. P., Coward, C. W., Kuhn, P., Nichols, M. R., Hewins, E. F., and Phillips, W. H., Similarities and contrasts between ship design and aircraft design, *Trans. Soc. nav. Arch. mar. Engrs.* **11**, 2, 1–20, July 1956.

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WILSON, A. H., Thermodynamics and statistical mechanics, New York, Cambridge University Press, 1957, xv + 495 pp.

GOODE, H. H., AND MACHOL, R. E., System engineering, New York, McGraw-Hill Book Company, Inc., Mar. 1957, 450 pp. $10.00.

DAWIHL, W., A handbook of hard metals, New York, The Philosophical Library, Inc., 1956, viii + 162 pp. $10.00.

ABBOTT, W., Practical geometry and engineering graphics, 6th ed., 1956, London, Blackie & Son Ltd., 366 pp. 22s. 6d. net.

MACKEY, C. O., BARNARD, W. N., ELLENWOOD, F. O., Engineering thermodynamics, New York, John Wiley & Sons, Inc., Mar. 1957, xvi + 428 pp. $7.95.

CADLE, R. D., Particle size determination, Manual 7, New York, Interscience Publishers, Inc., 1955, xv + 303 pp. $5.50.

DONOVAN, A. F., AND LAWRENCE, H. R., edited by, High speed aerodynamics and jet propulsion, Vol. 7: Aerodynamic components of aircraft at high speeds, New Jersey, Princeton University Press, 1957, xiv + 845 pp. $17.50.

BIRKHOFF, G., AND ZARANTONELLO, E. H., Applied mathematics and mechanics, Vol. 2: Jets, wakes and cavities, New York, Academic Press Inc., Mar. 1957, xii + 353 pp.

JAEGER, C., Engineering fluid mechanics, London, Blackie & Son Ltd., 1956, xviii + 529 pp. 60s. net.

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